USGS
science for a changing world

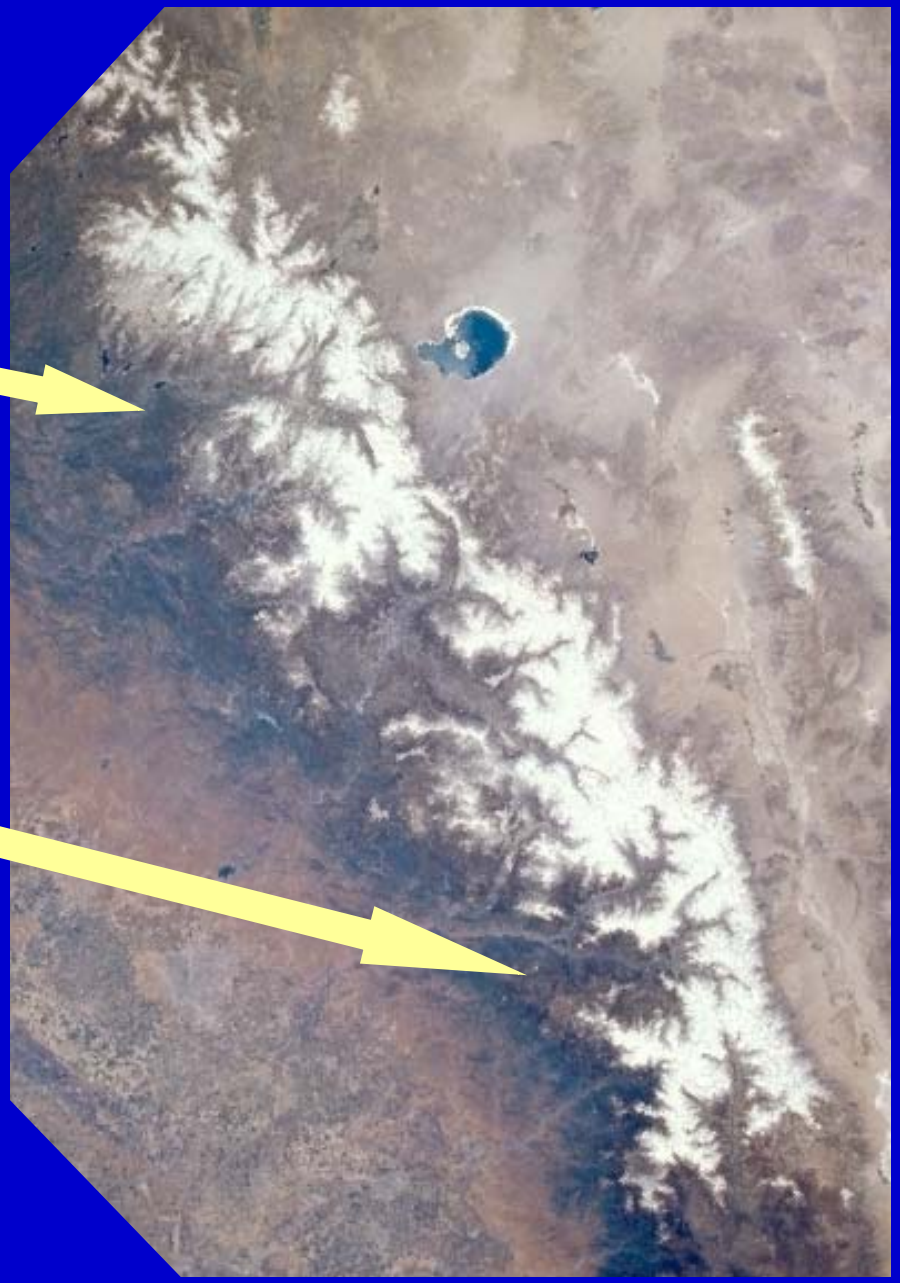
Mountain Climatic Gradients as Natural Ecological Experiments

Results from the Sierra Nevada Global Change Research Program

U.S. Department of the Interior
U.S. Geological Survey

Yosemite

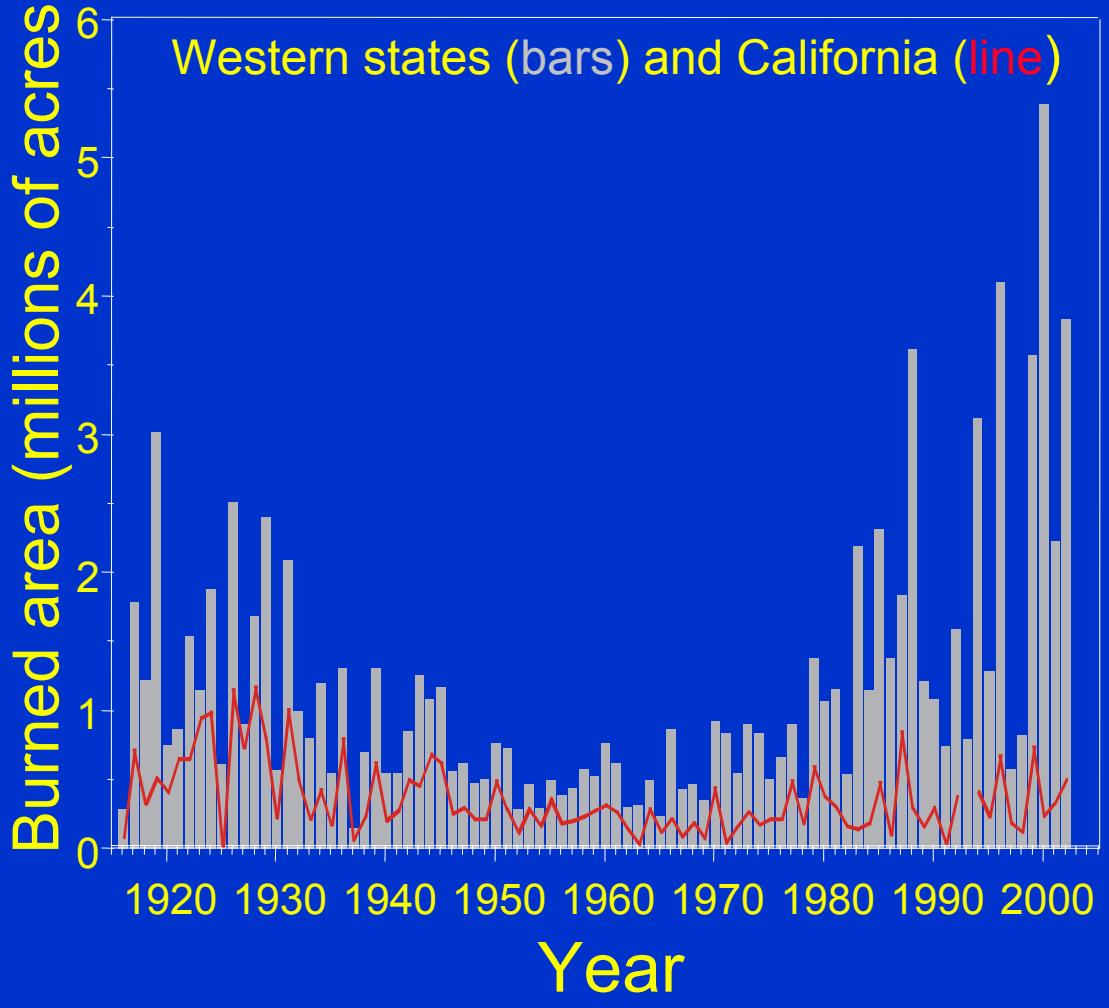
Sequoia and
Kings Canyon



USGS

Acres Burned - 1916 to 2002

(From Arno 1996, updated by Caprio 2002)



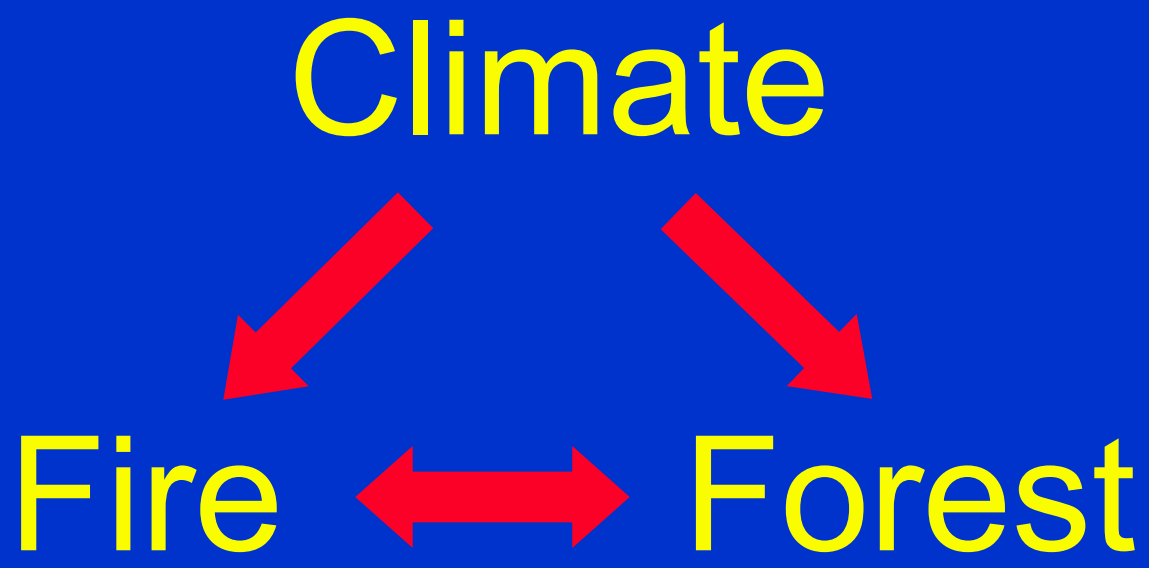
USGS

Goal:

To understand and predict the effects of global changes (particularly changing climate and fire regimes) on montane forests.

USGS

Approach



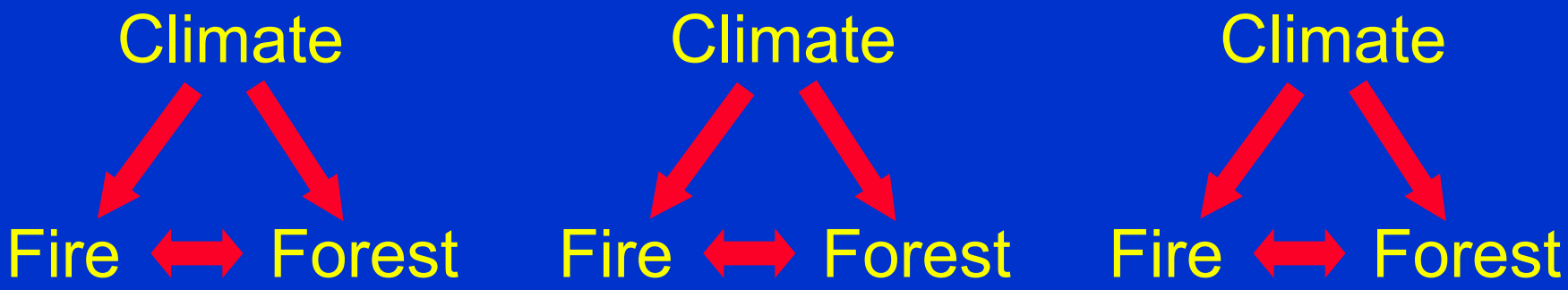
USGS

Approach (cont.)

Paleoecology
(Variation in time)

Contemporary ecology
(Variation in space)

Modeling
(Explore sensitivities, future scenarios)



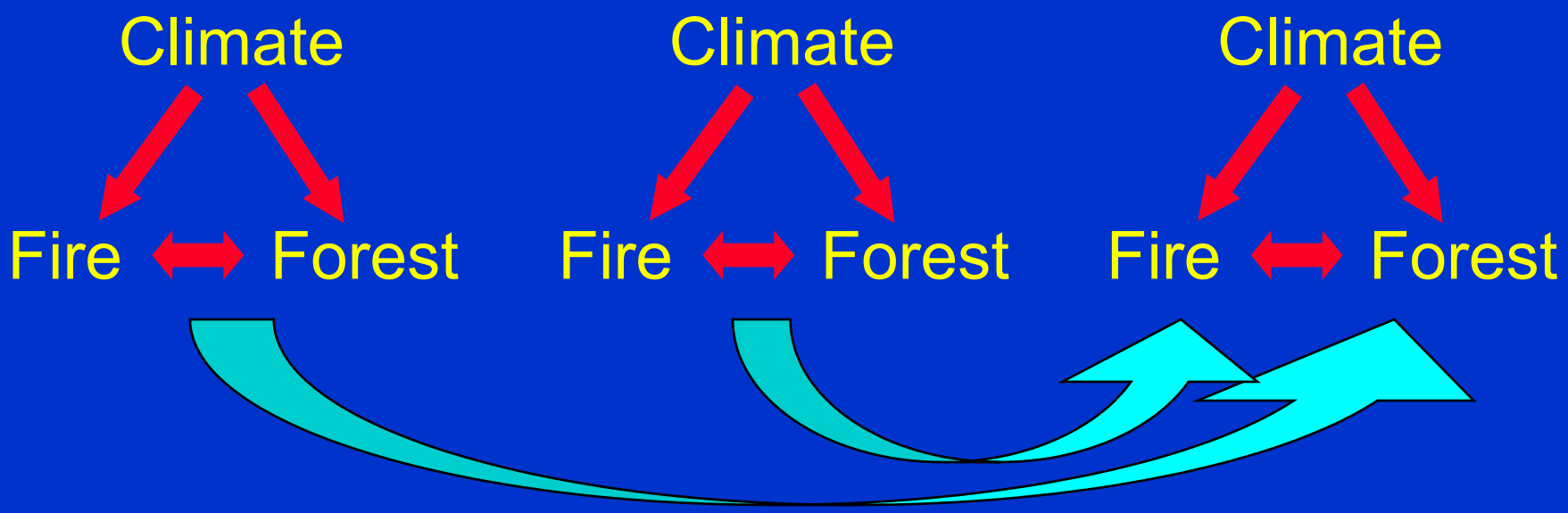
USGS

Approach (cont.)

Paleoecology
(Variation in time)

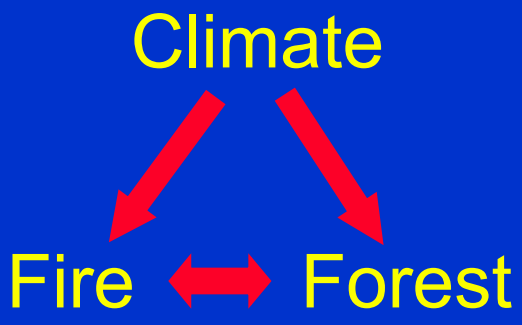
Contemporary ecology
(Variation in space)

Modeling
(Explore sensitivities, future scenarios)

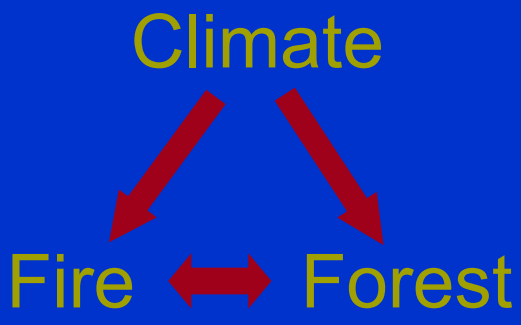


USGS

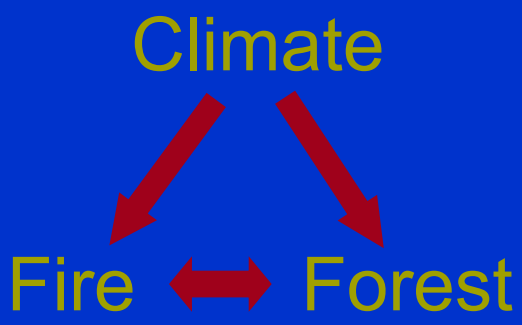
Paleoecology
(Variation in time)



Contemporary ecology
(Variation in space)

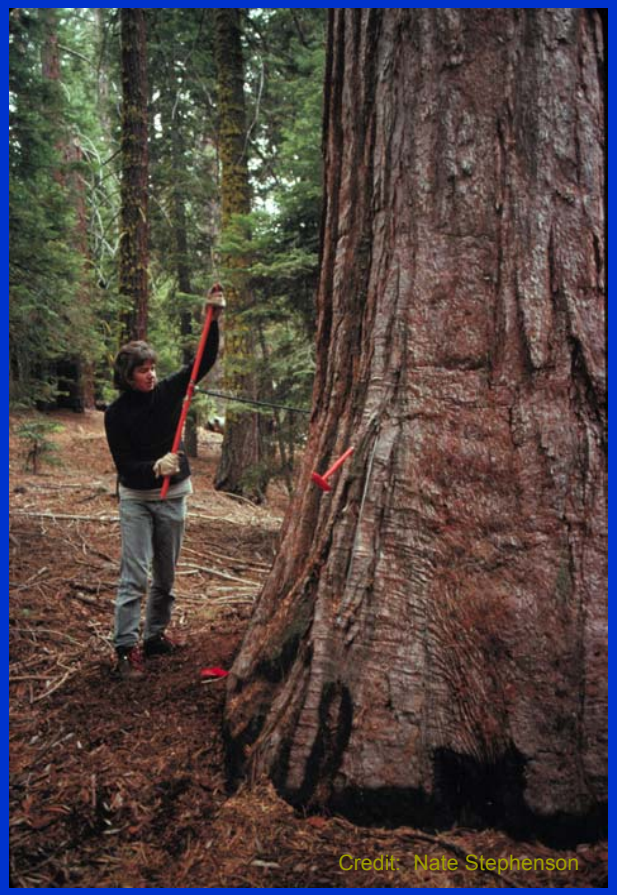


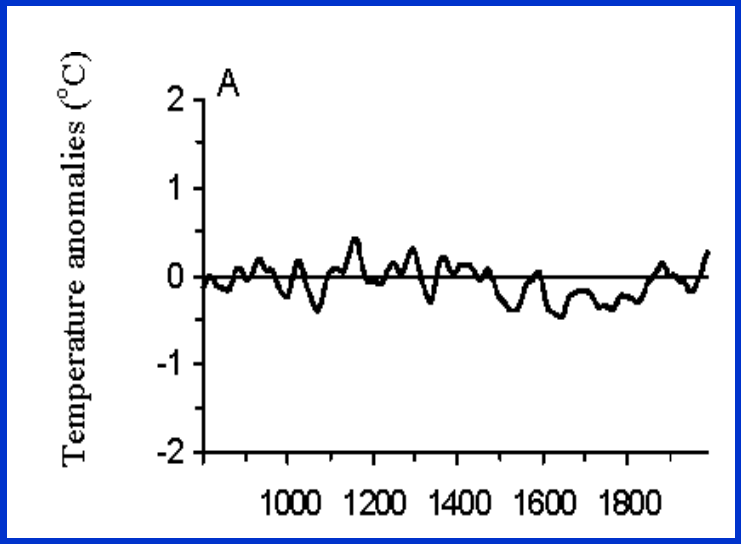
Modeling
(Explore sensitivities, future scenarios)

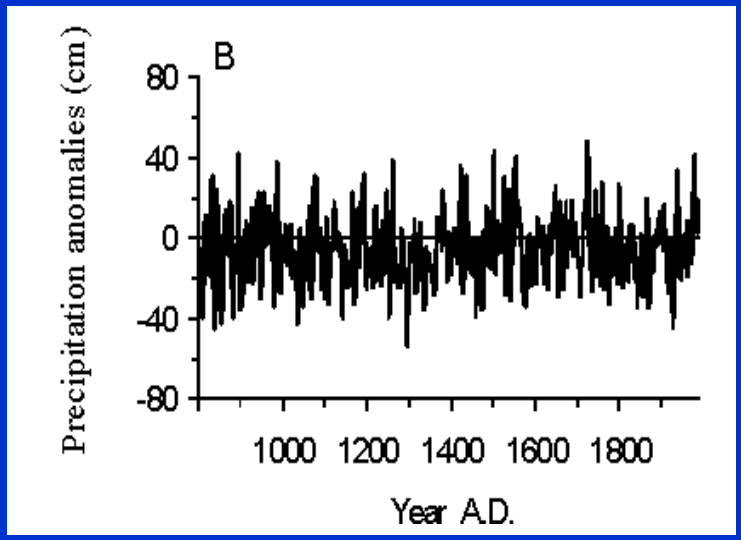


USGS

Paleoclimate from tree rings (Graumlich and Hughes)

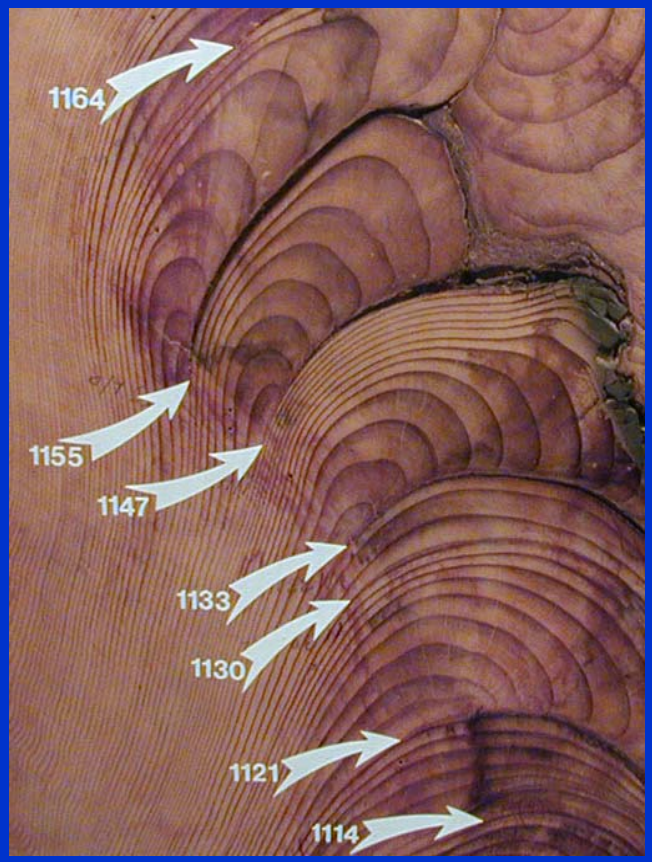




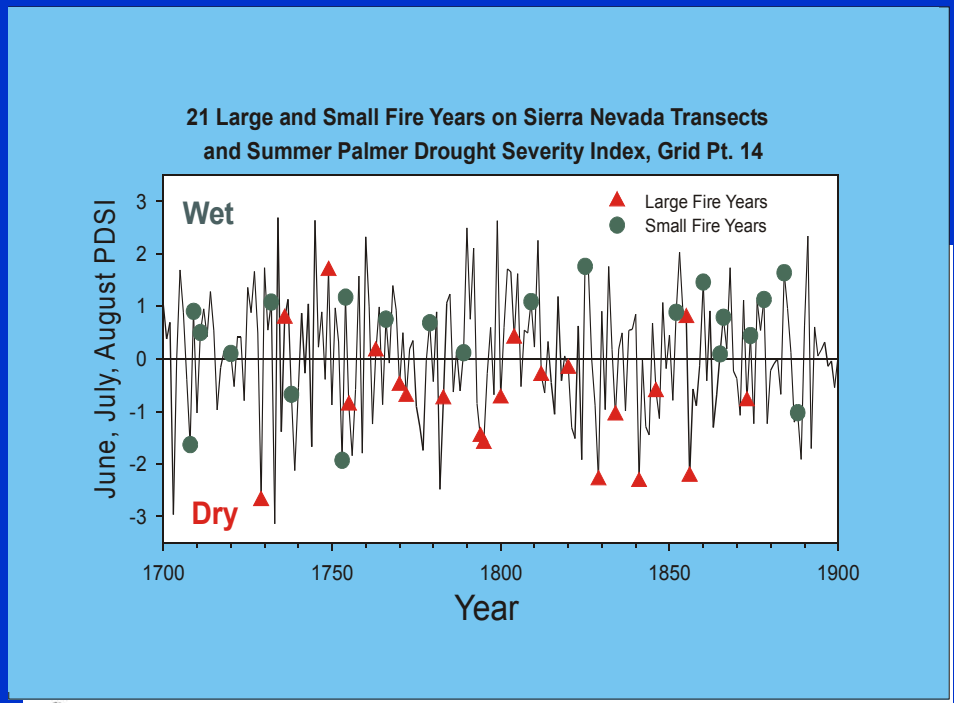


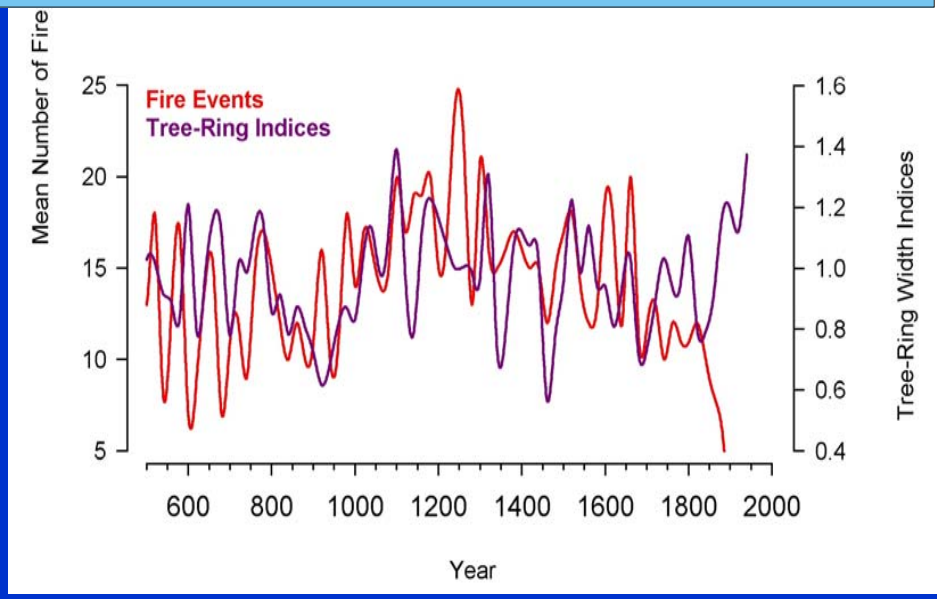
USGS

Paleo-fire from tree rings (Swetnam et al.)



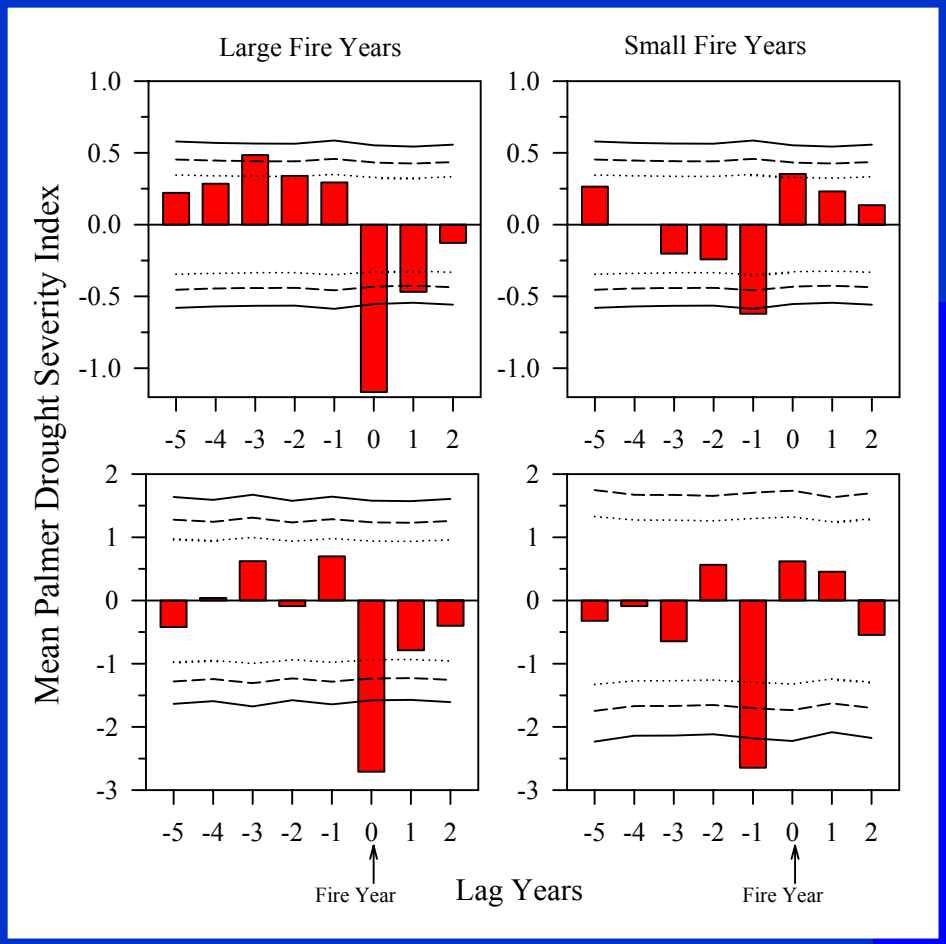
Credit: Tom Swetnam

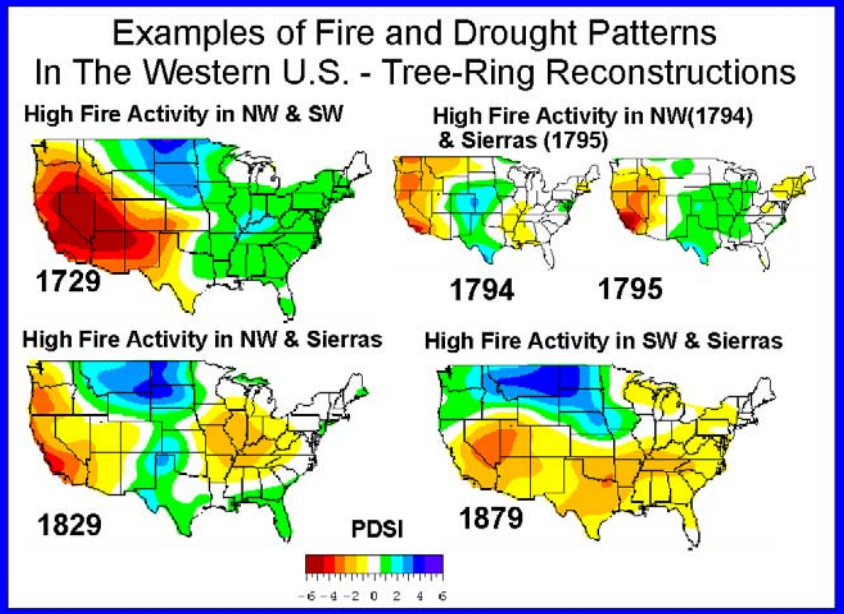




USGS

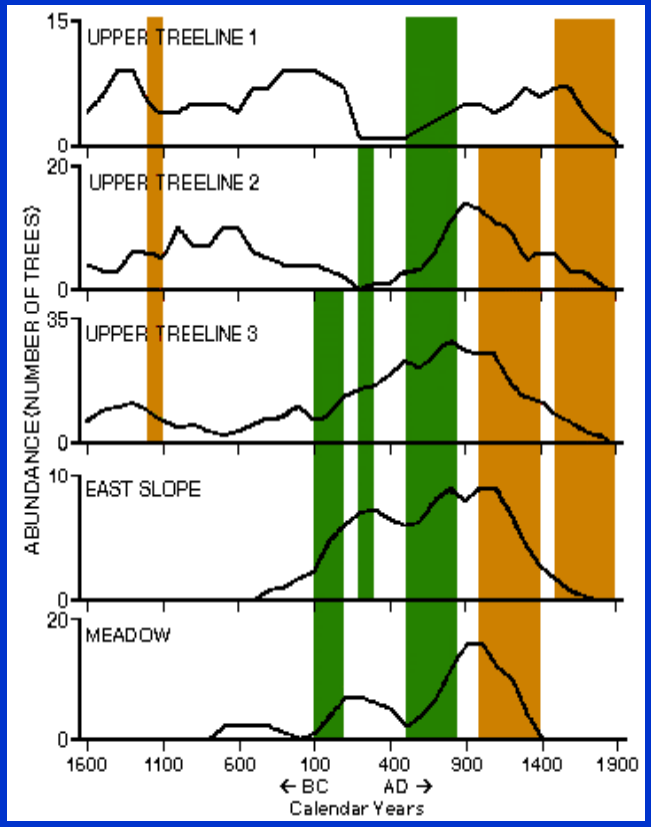
Regional paleo-fire patterns

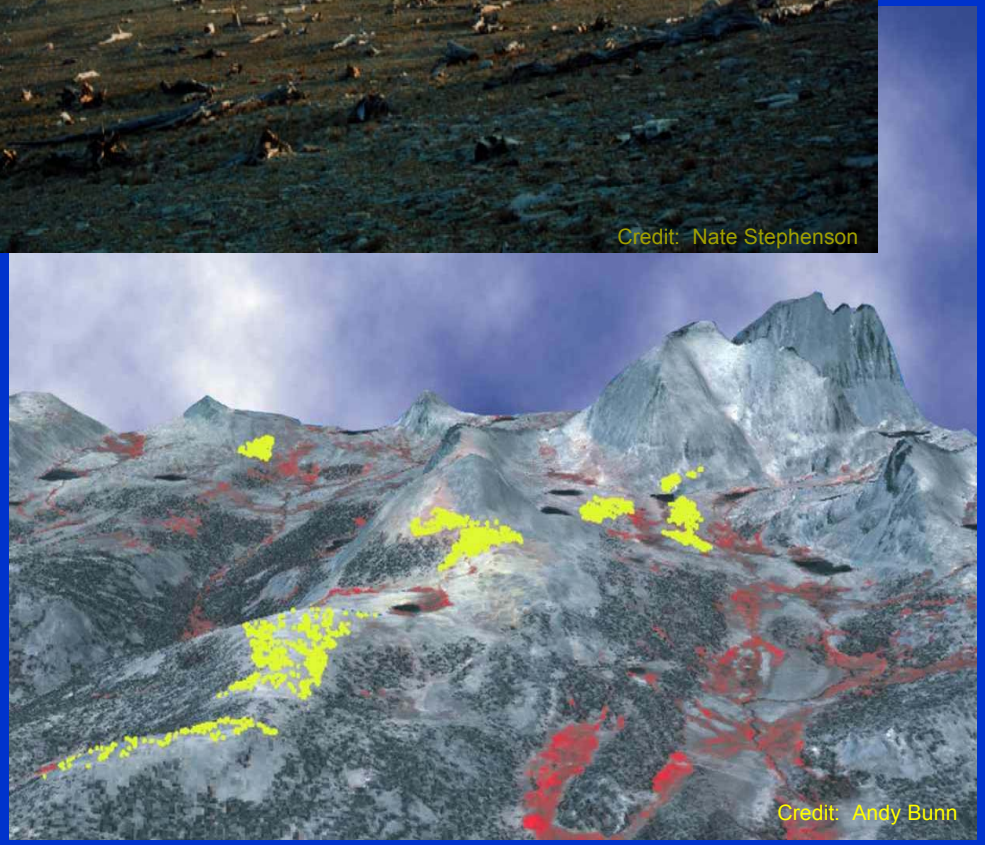




USGS

Treeline response (Graumlich, Lloyd, and Bunn)



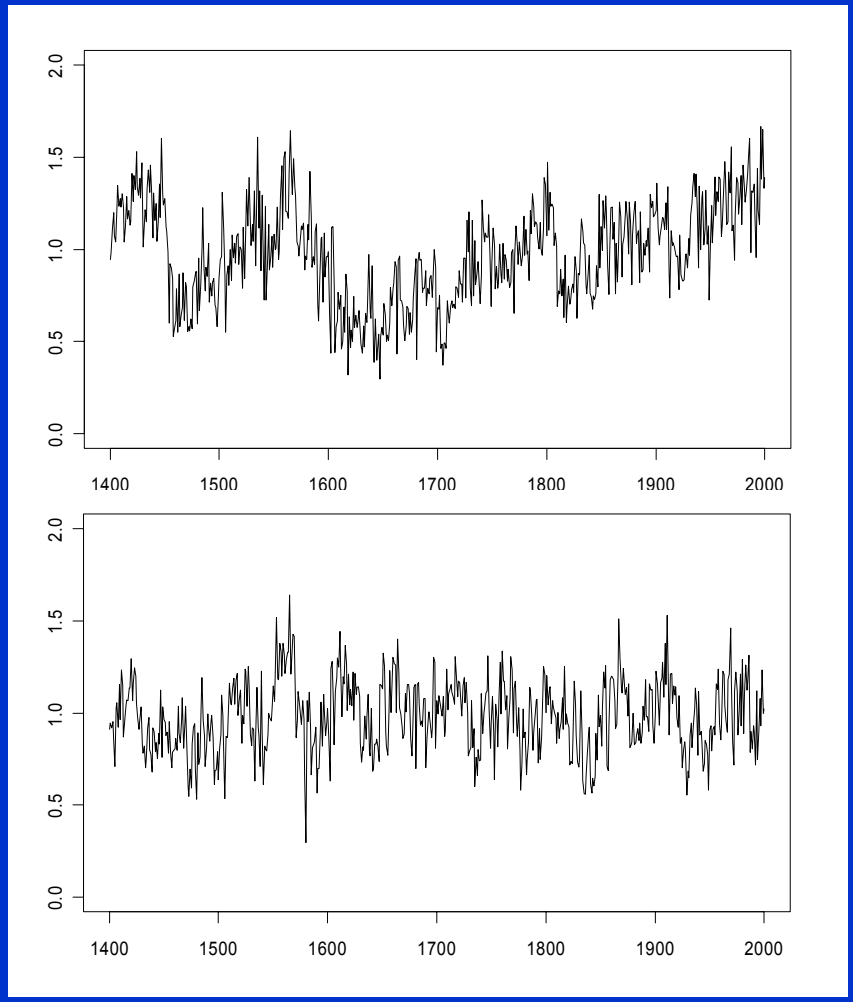


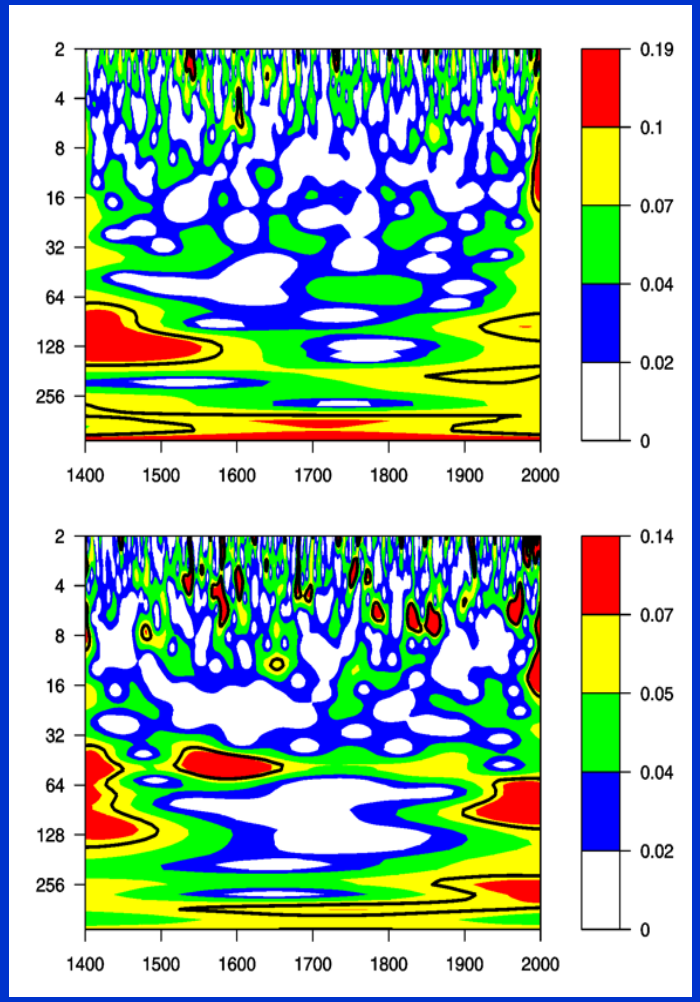
USGS

Wavelet power spectra

Wet and bright

Dry and dark

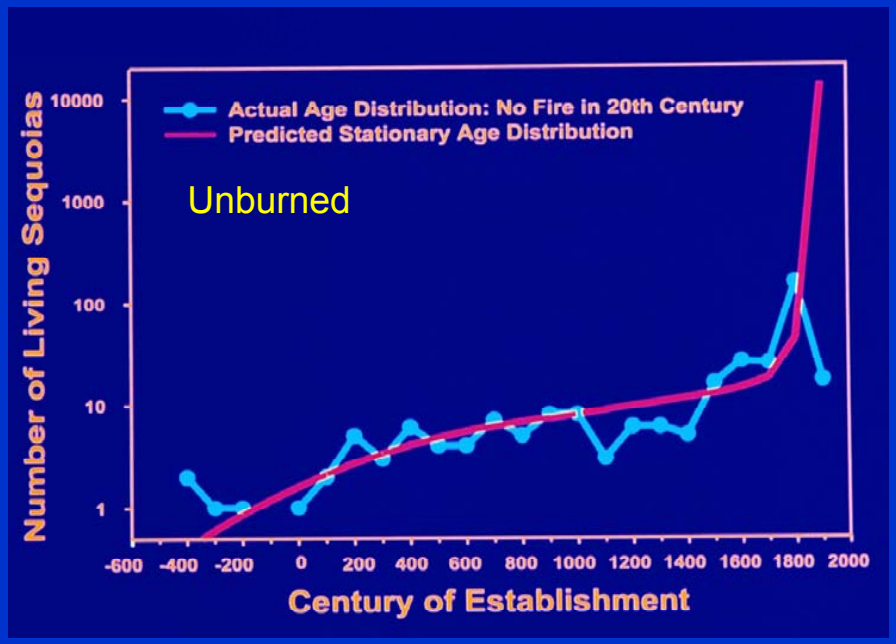


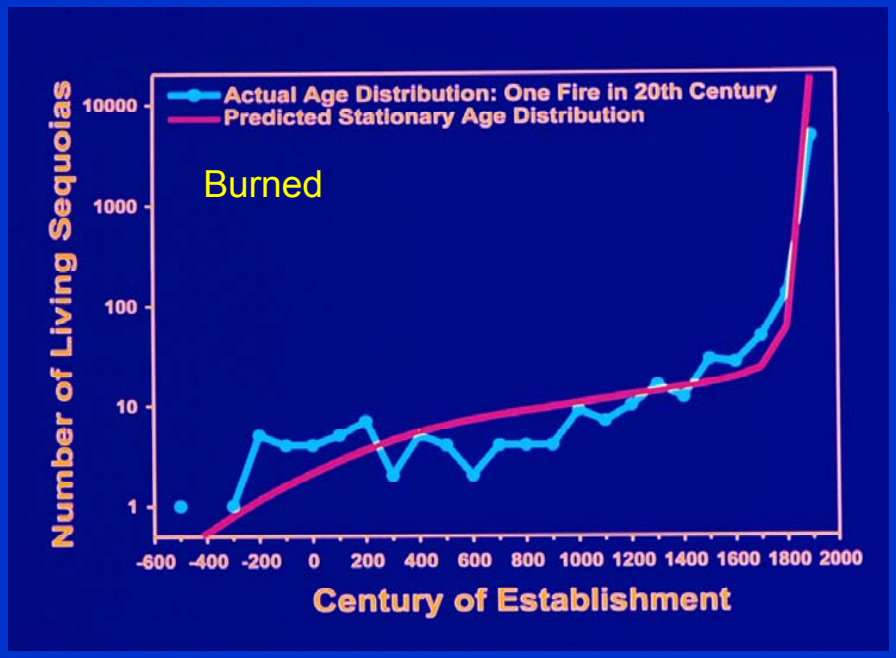


Bunn et al. (*in review*)

USGS

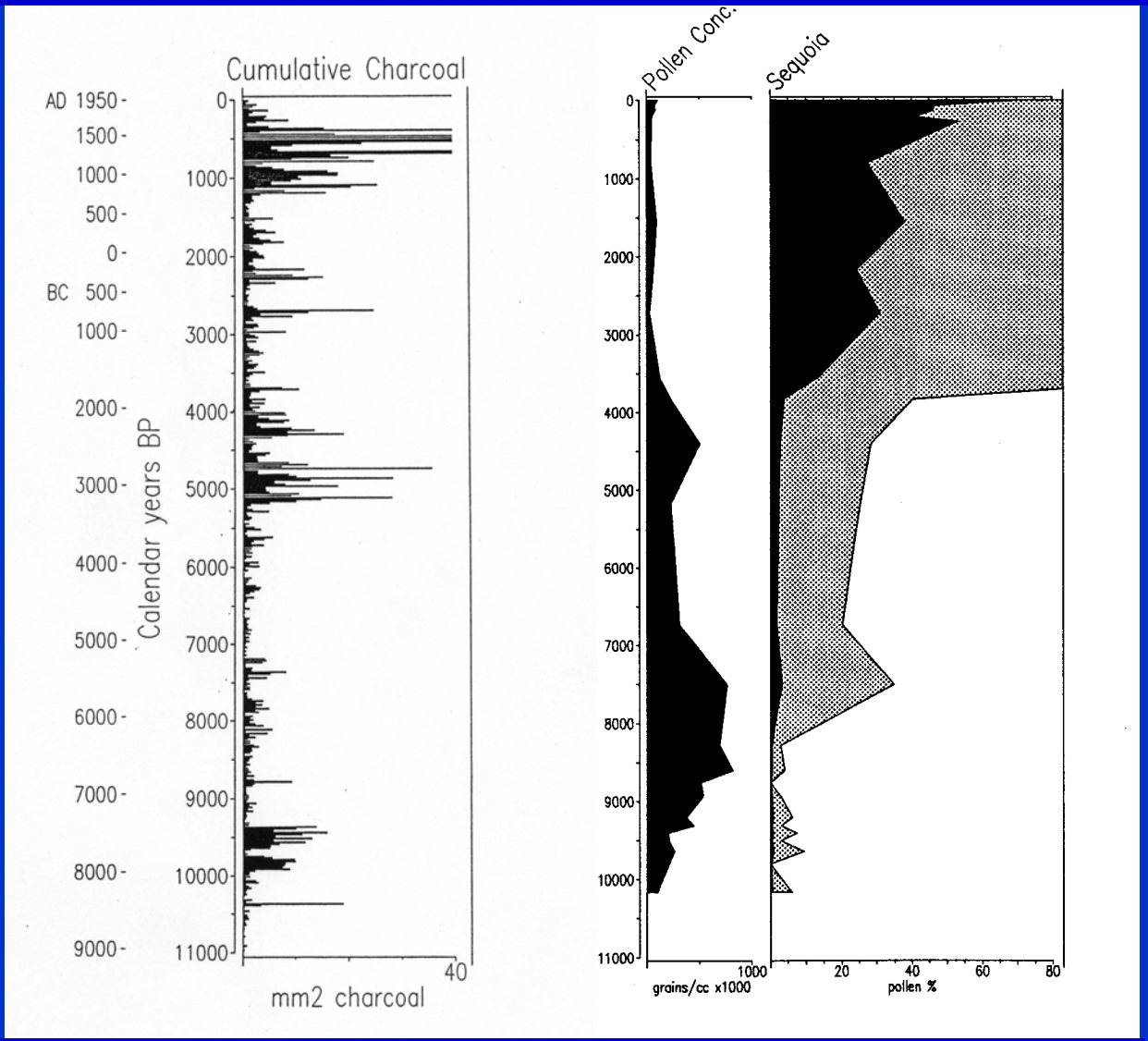
Sequoia forest response (Stephenson)





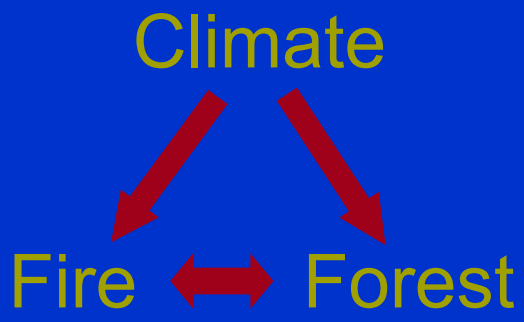
USGS

Long-term changes in charcoal and vegetation (Anderson)

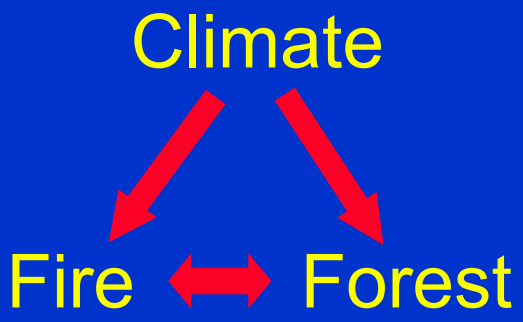


USGS

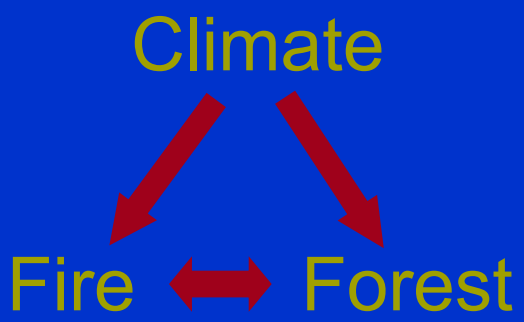
Paleoecology
(Variation in time)



Contemporary ecology
(Variation in space)

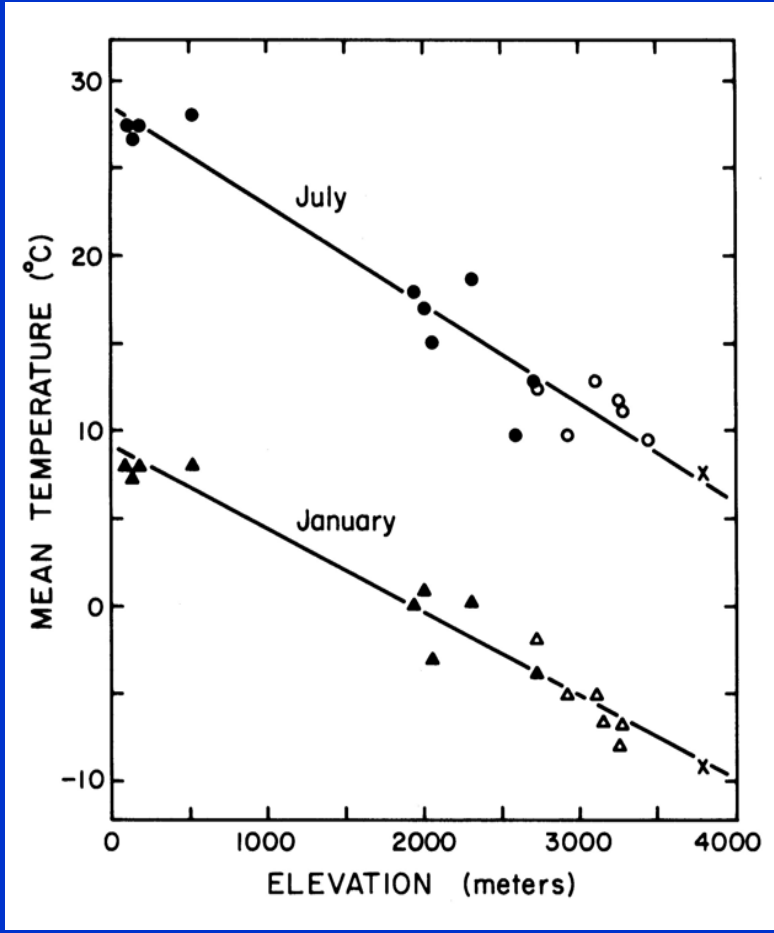


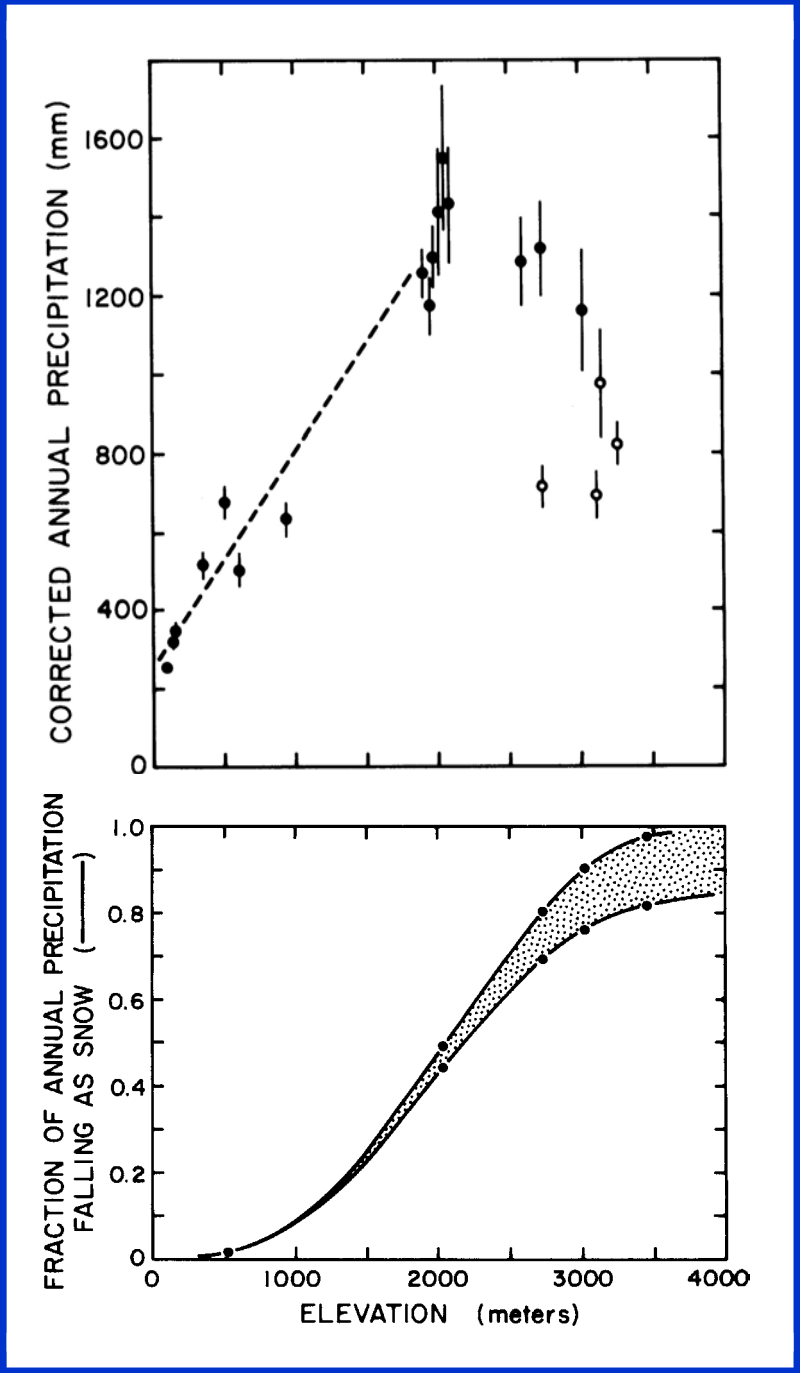
Modeling
(Explore sensitivities, future scenarios)



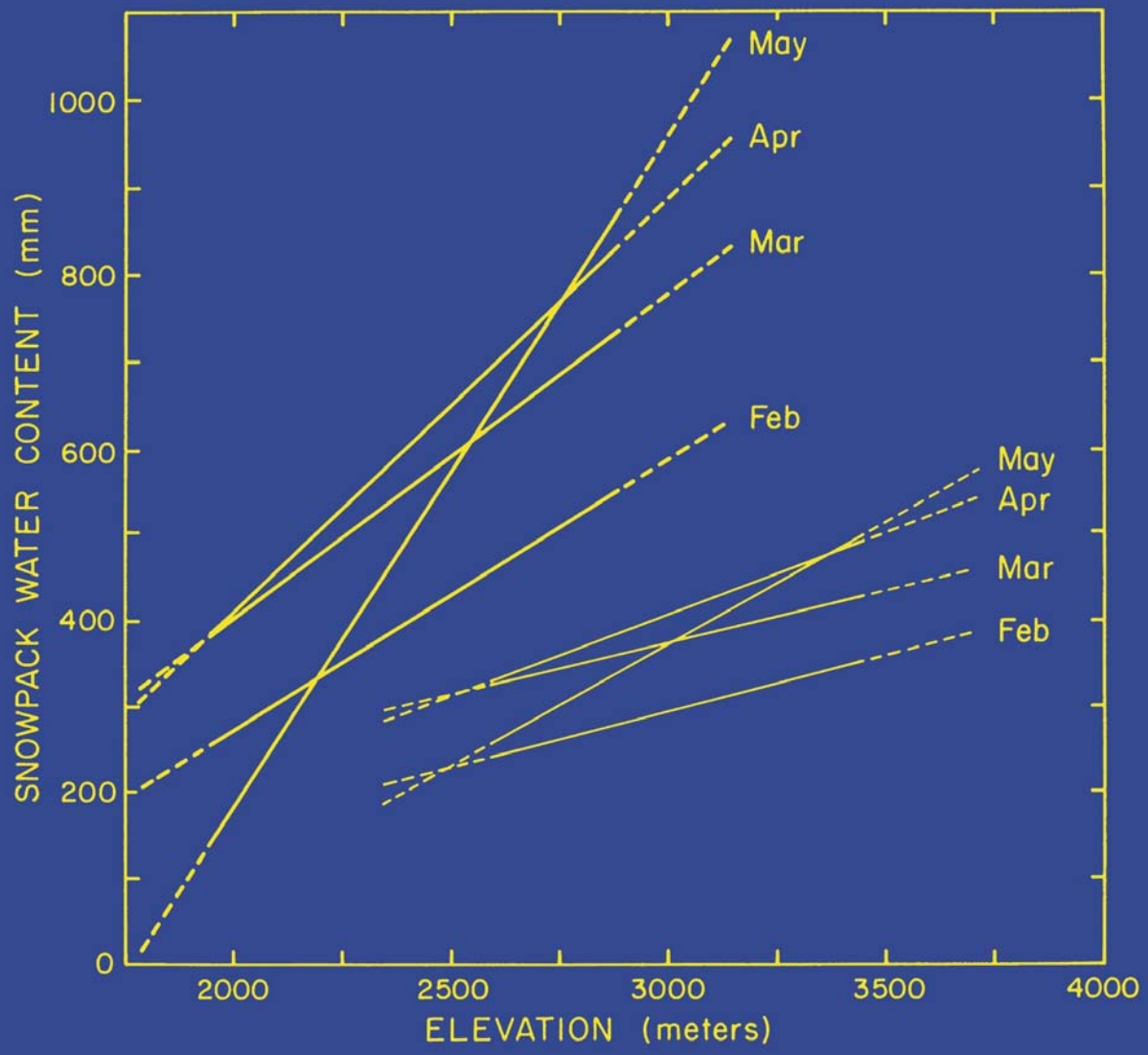
USGS

Contemporary climate (Stephenson et al.)

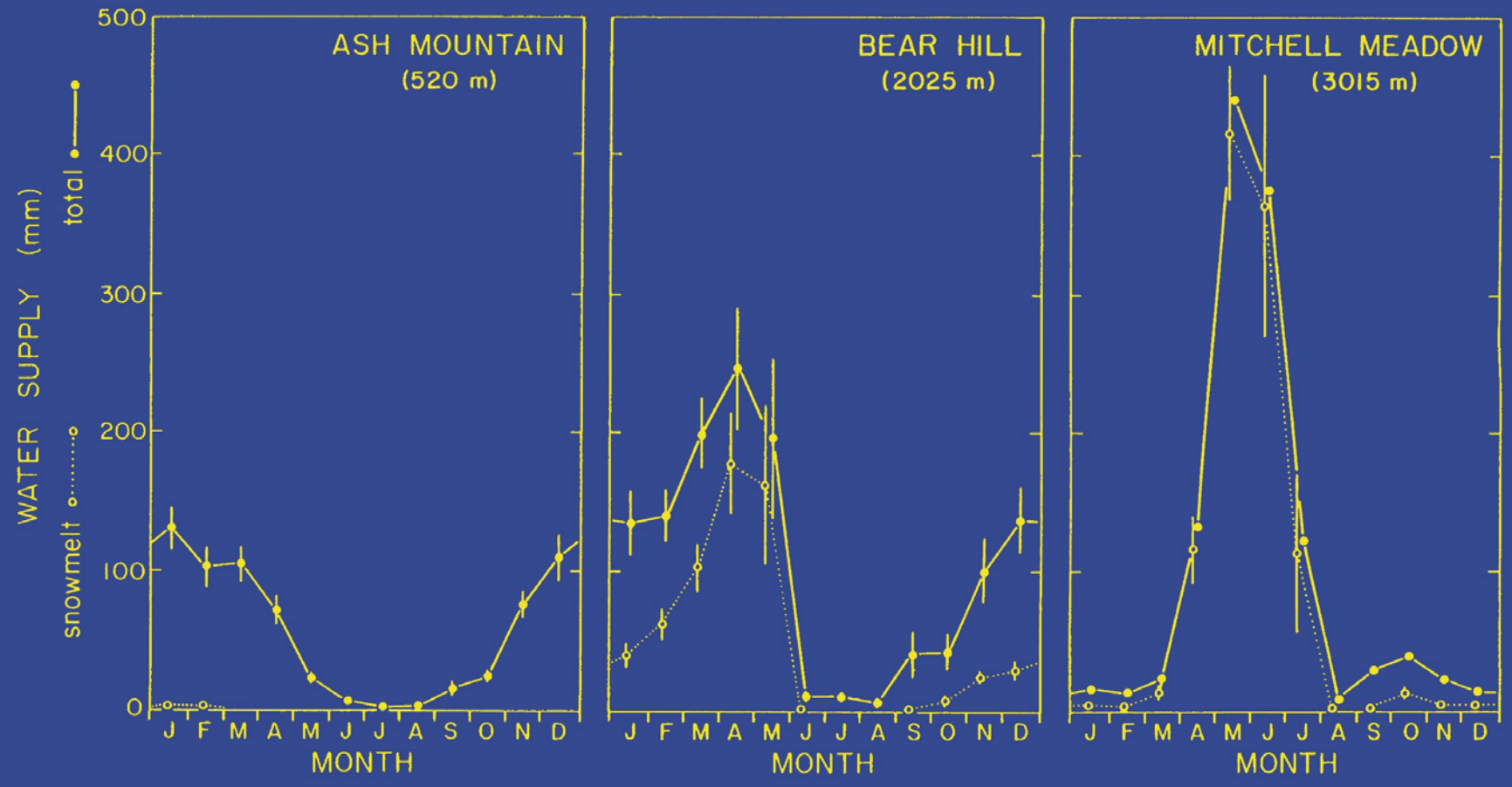




USGS


SNOWPACK WATER CONTENT (mm)
1000
800
600
400
200
0
2000
2500
3000
3500
4000
ELEVATION (meters)
May
Apr
Mar
Feb
May
Apr
Mar
Feb

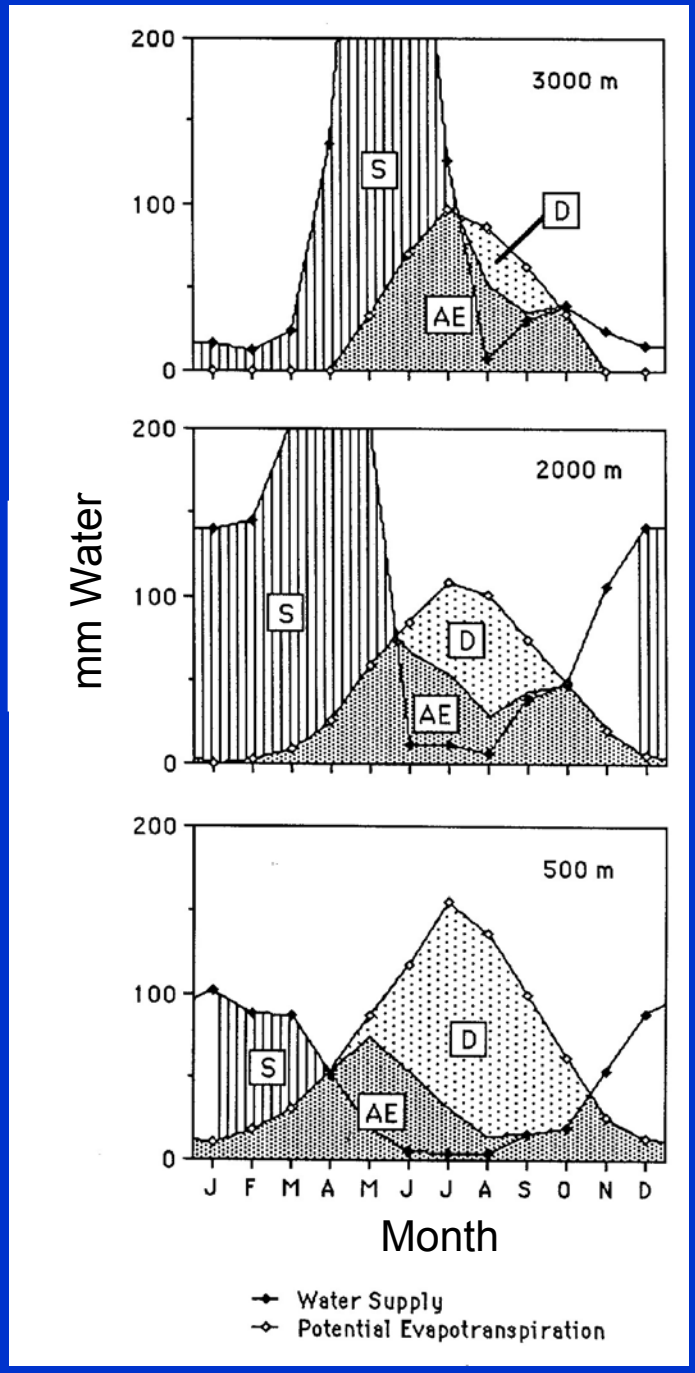
USGS

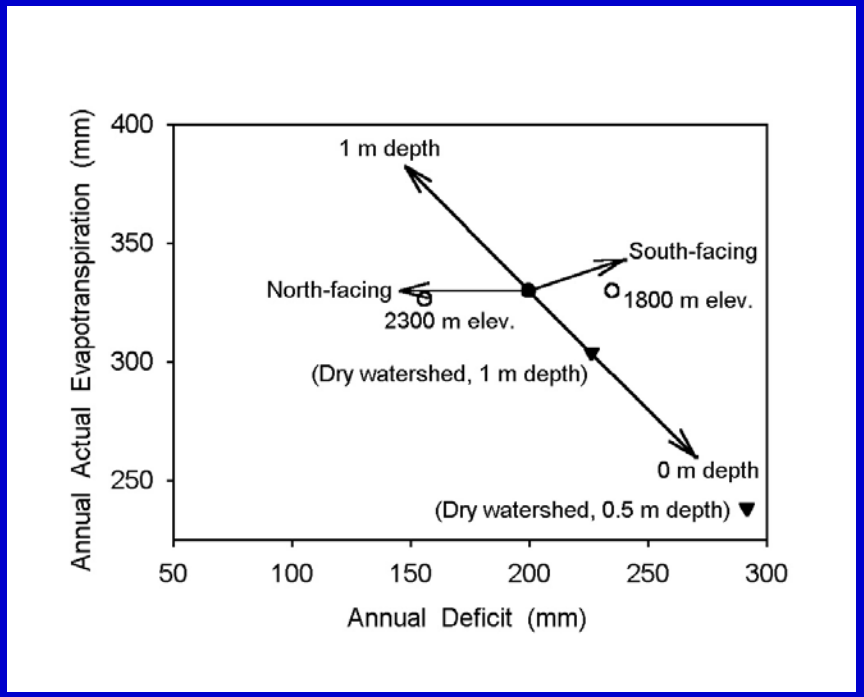

ASH MOUNTAIN
(520 m)
BEAR HILL
(2025 m)
MITCHELL MEADOW
(3015 m)
WATER SUPPLY (mm)
snowmelt
total
500
400
300
200
100
0
J F M A M J J A S O N D
MONTH

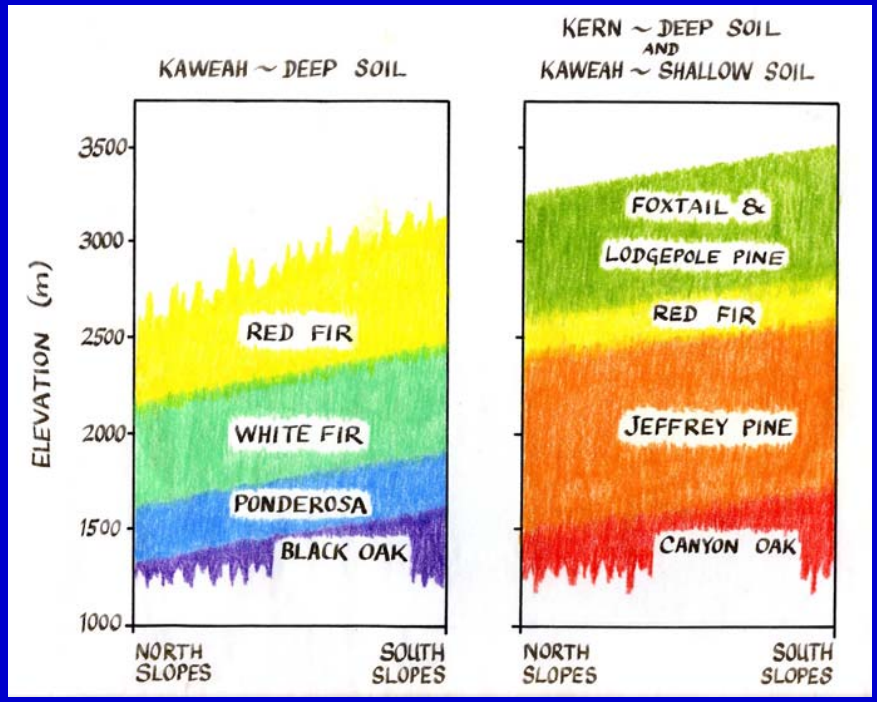
USGS

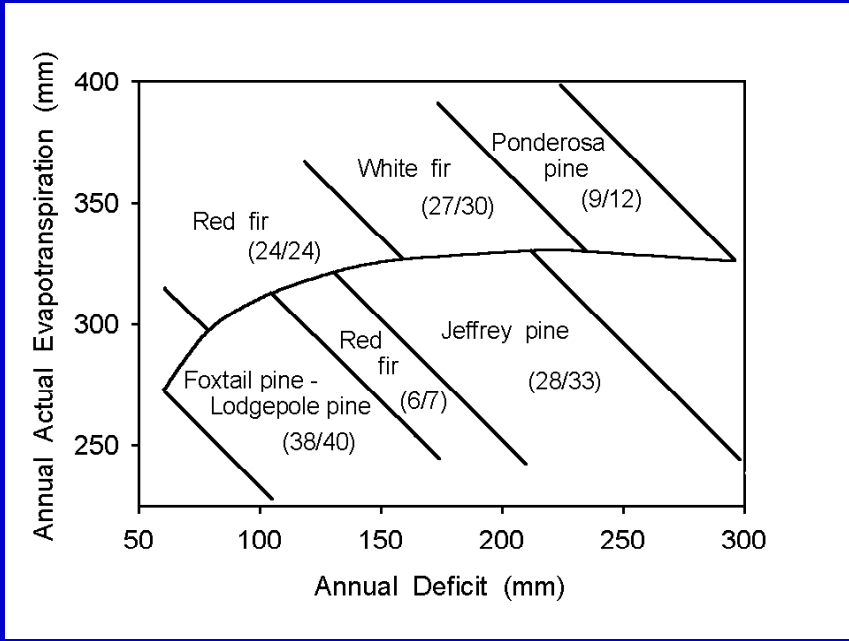

Credit: Tony Caprio

USGS


200
100
0
3000 m
S
D
AE
2000 m
500 m
mm Water
J F M A M J J A S O N D
Month
Water Supply
Potential Evapotranspiration

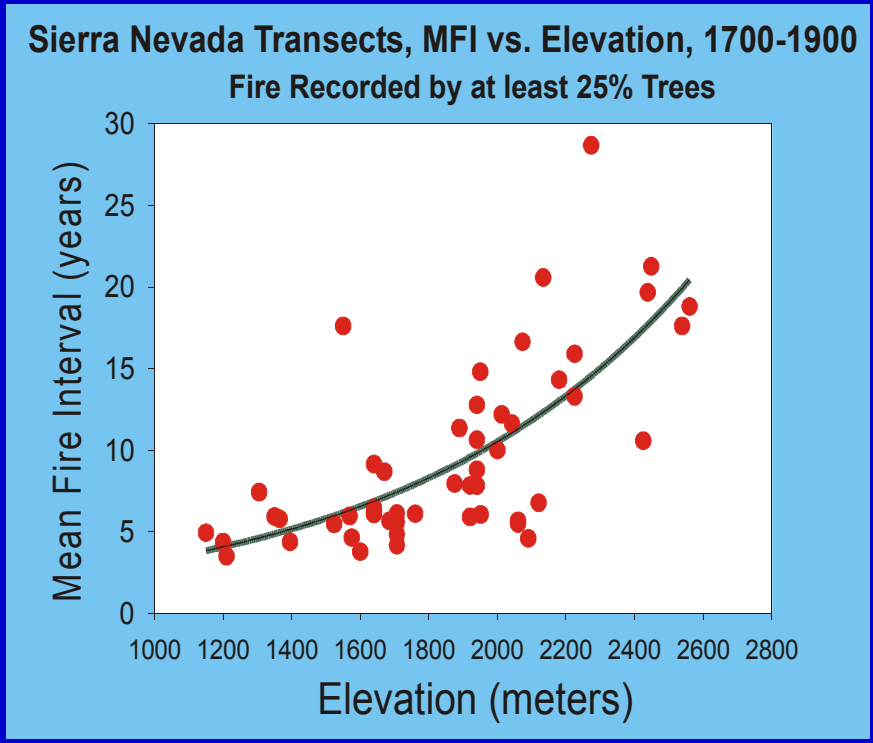

Annual Actual Evapotranspiration (mm)
400
350
300
250
1 m depth
South-facing
North-facing
1800 m elev.
2300 m elev.
(Dry watershed, 1 m depth)
0 m depth
(Dry watershed, 0.5 m depth)
50
100
150
200
250
300
Annual Deficit (mm)

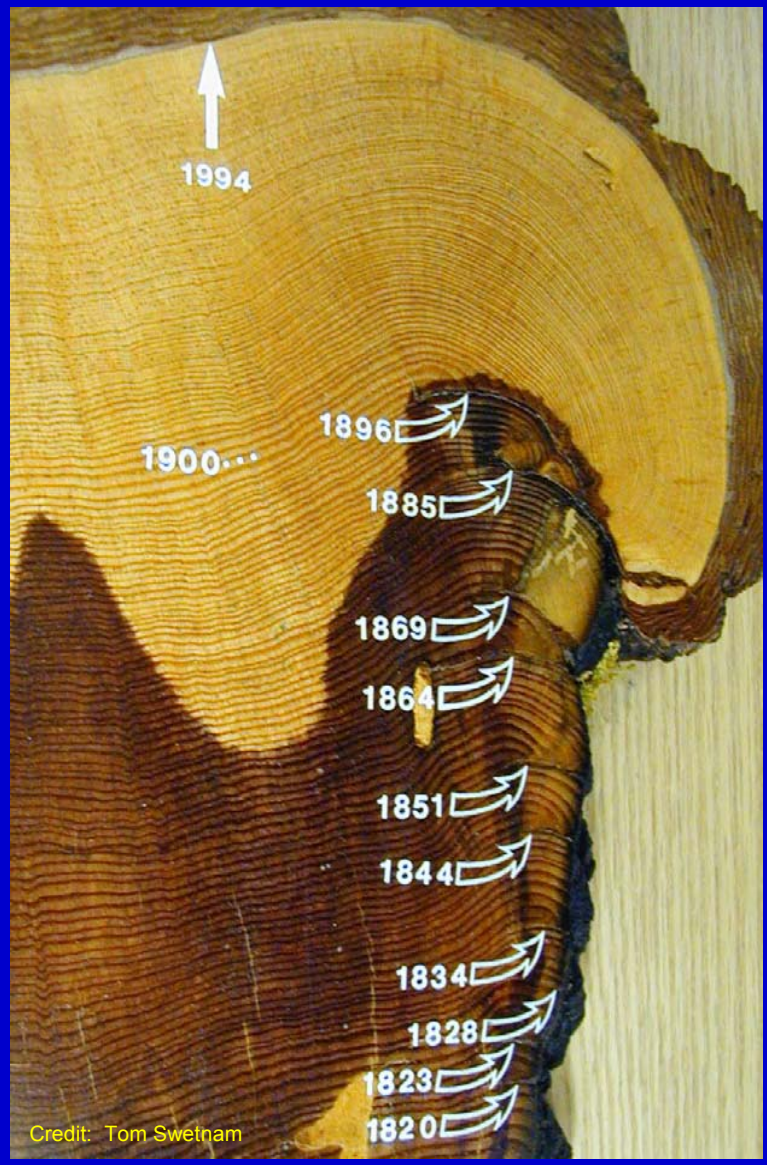

KAWEAH ~ DEEP SOIL
KERN ~ DEEP SOIL
AND
KAWEAH ~ SHALLOW SOIL
ELEVATION (m)
3500
3000
2500
2000
1500
1000
RED FIR
WHITE FIR
PONDEROSA
BLACK OAK
FOXTAIL &
LODGEPOLE PINE
RED FIR
JEFFREY PINE
CANYON OAK
NORTH SLOPES
SOUTH SLOPES
NORTH SLOPES
SOUTH SLOPES


Annual Actual Evapotranspiration (mm)
400
350
300
250
White fir
(27/30)
Ponderosa
pine
(9/12)
Red fir
(24/24)
Red
fir
(6/7)
Jeffrey pine
(28/33)
Foxtail pine -
Lodgepole pine
(38/40)
50
100
150
200
250
300
Annual Deficit (mm)

USGS

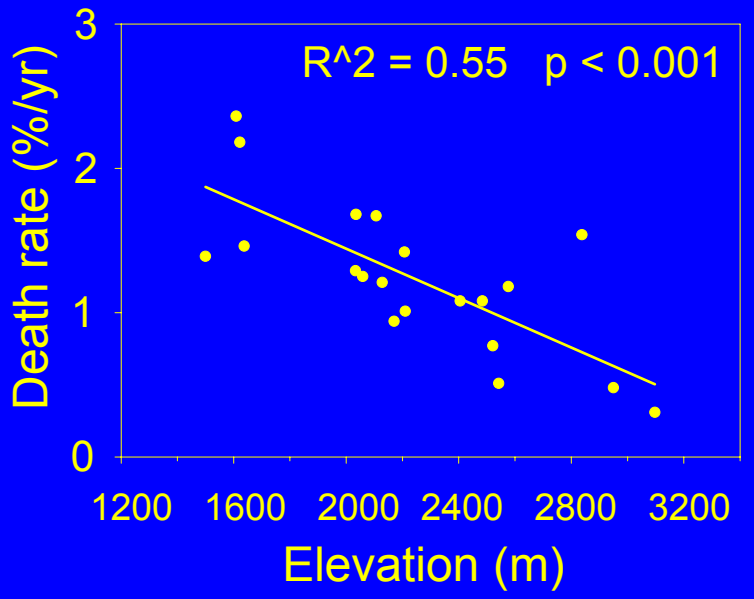
Fire, elevation and topography (Swetnam, Caprio, et al.)

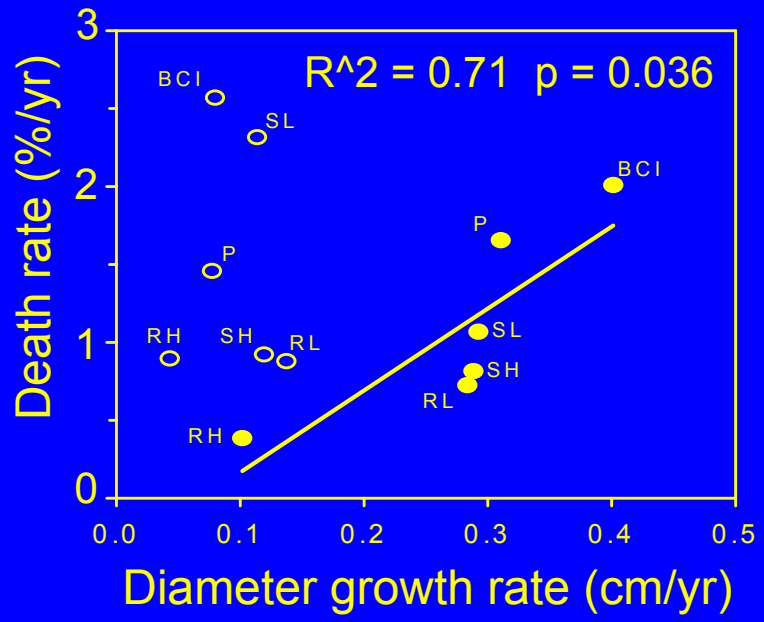




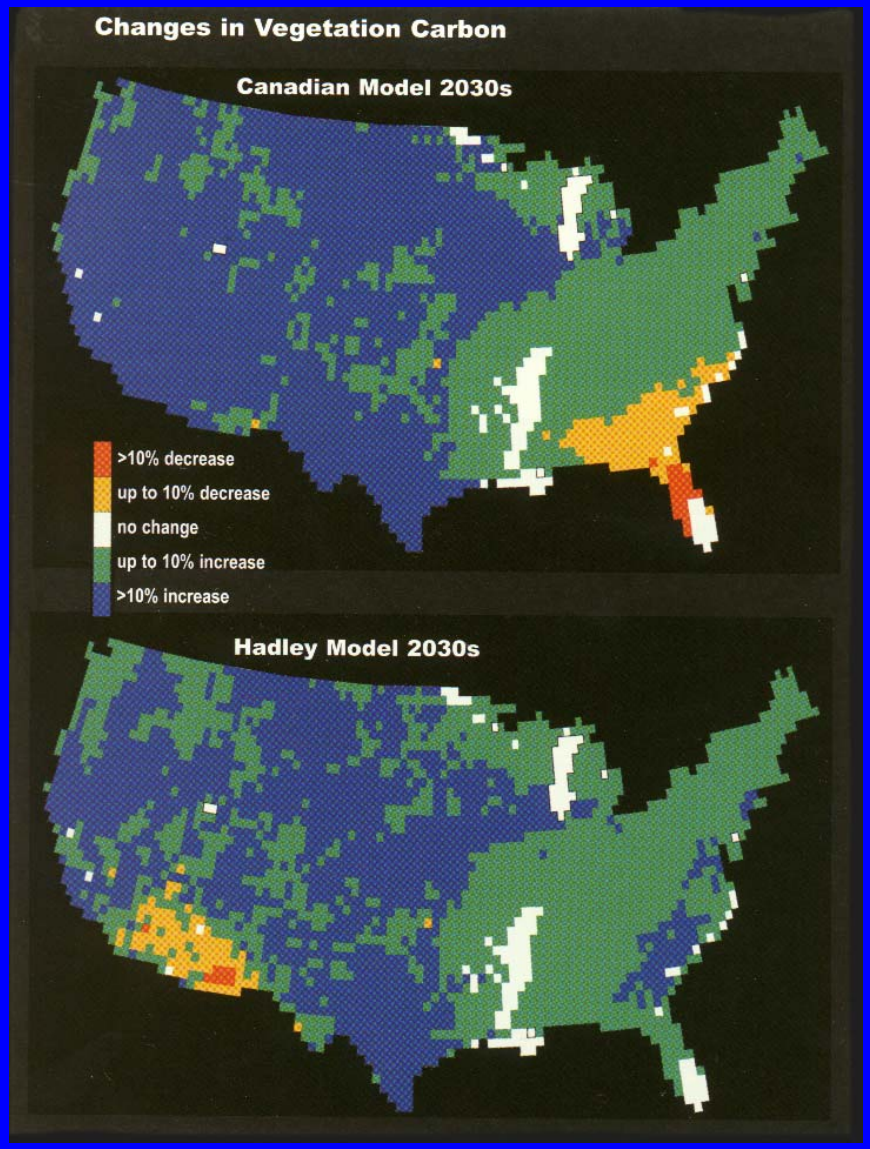
USGS

Contemporary forest and fire dynamics (Stephenson, Keeley, van Wagtendonk, and van Mantgem)

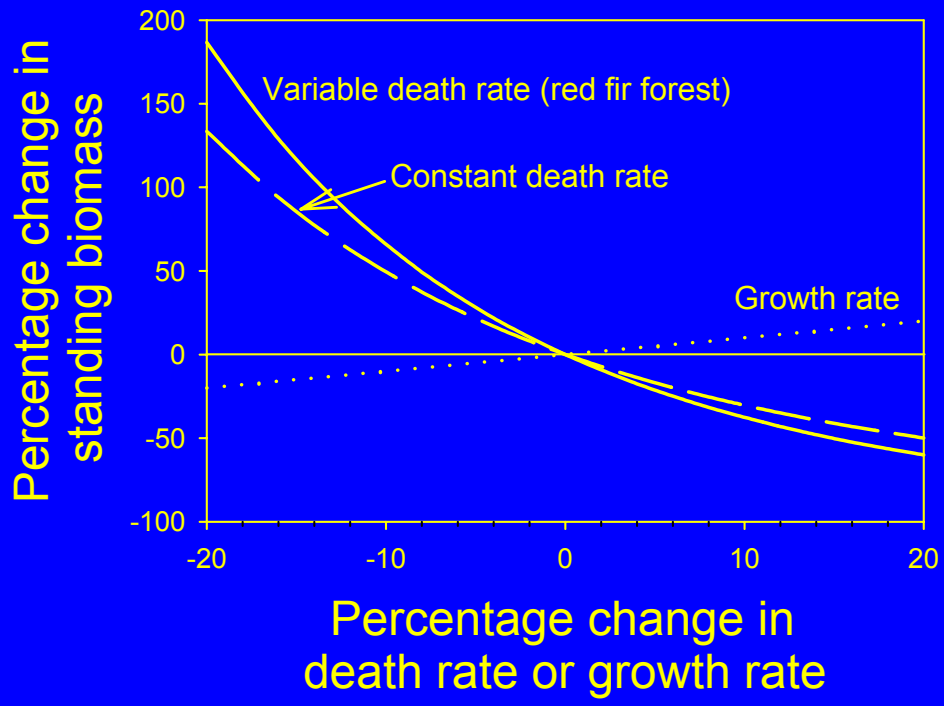




USGS

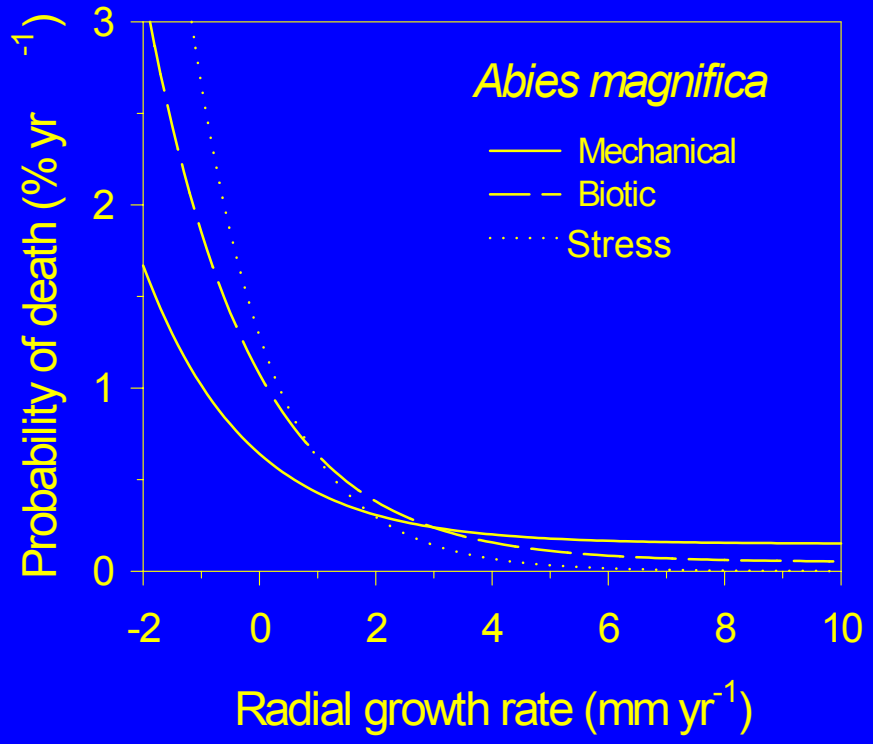


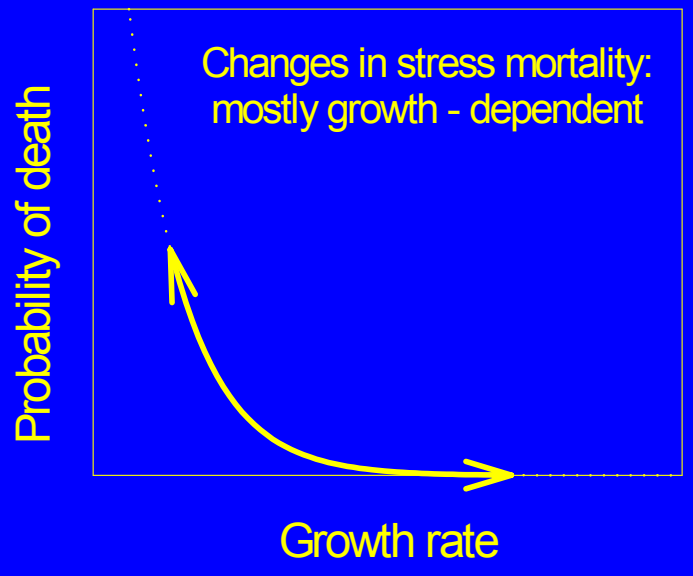
Implications for forest carbon dynamics

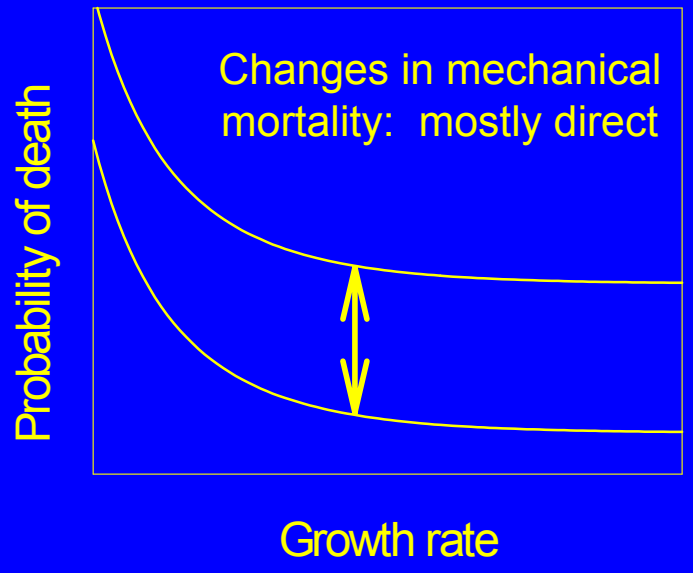


USGS

Implications for forest response to stress (and forest modeling)





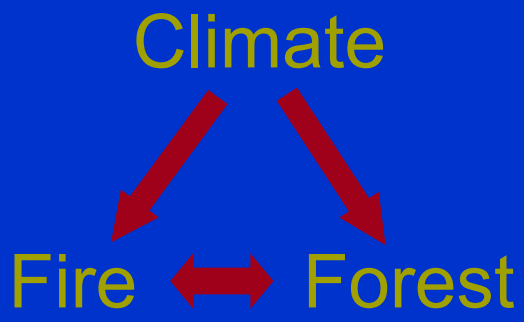


USGS

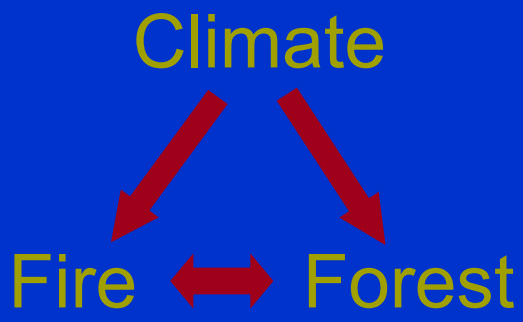
Implications for forest response to stress: Fire and interacting stress

USGS

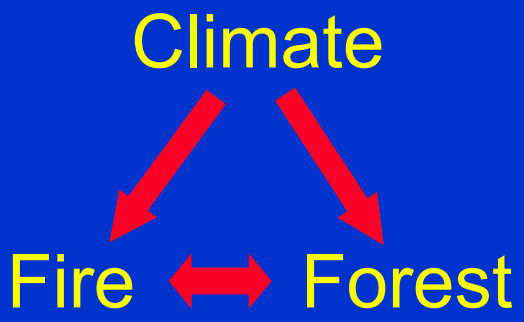
Paleoecology
(Variation in time)



Contemporary ecology
(Variation in space)

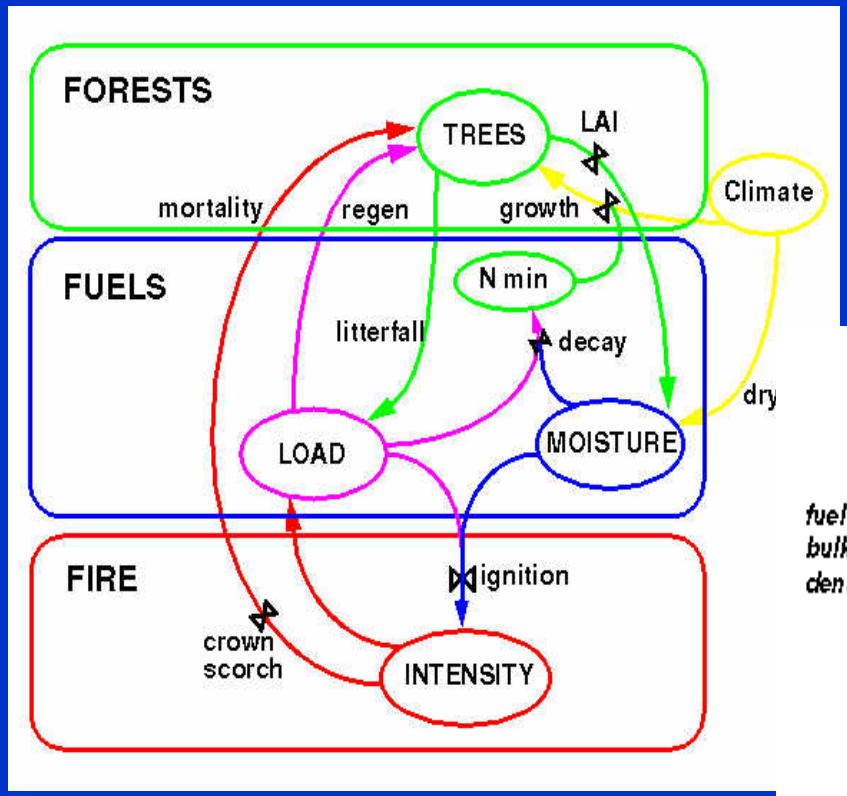


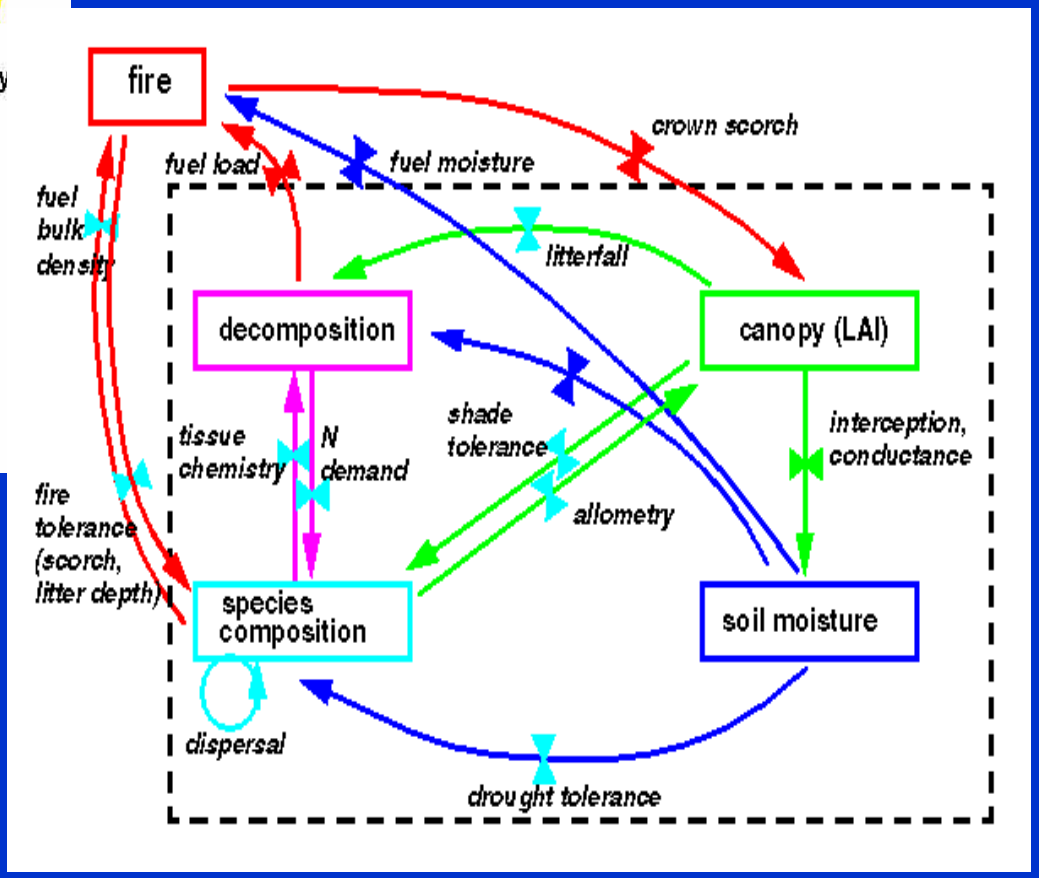
Modeling
(Explore sensitivities, future scenarios)



USGS

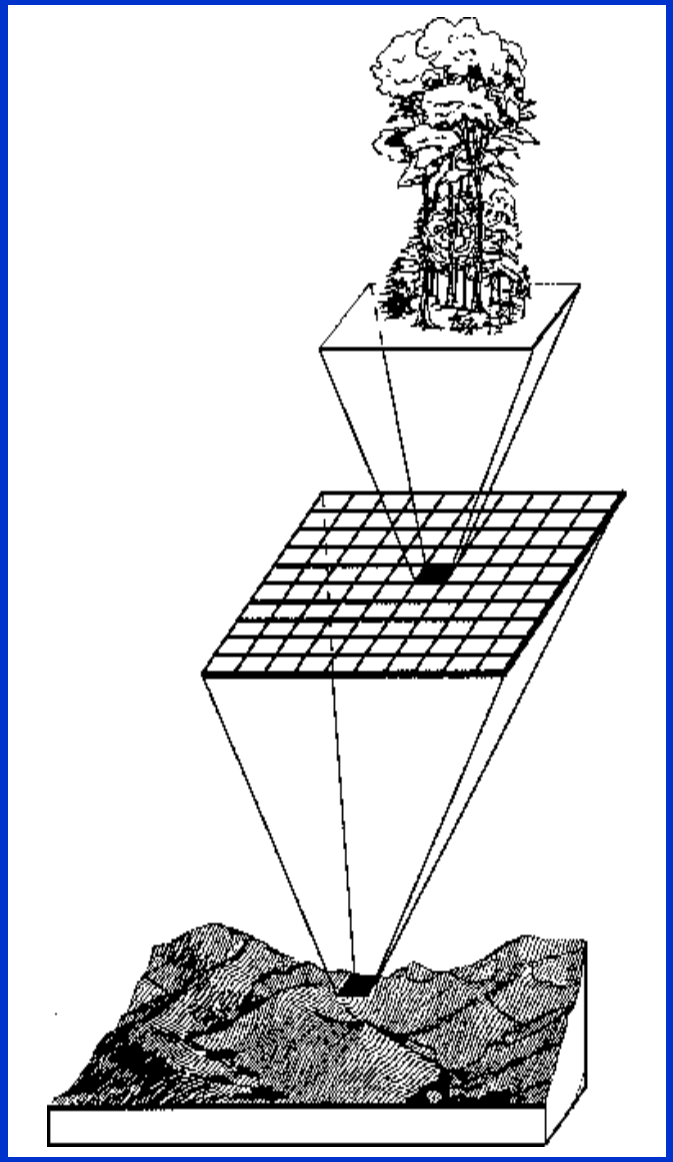
Modeling: an integrative framework (Urban, Miller, et al.)

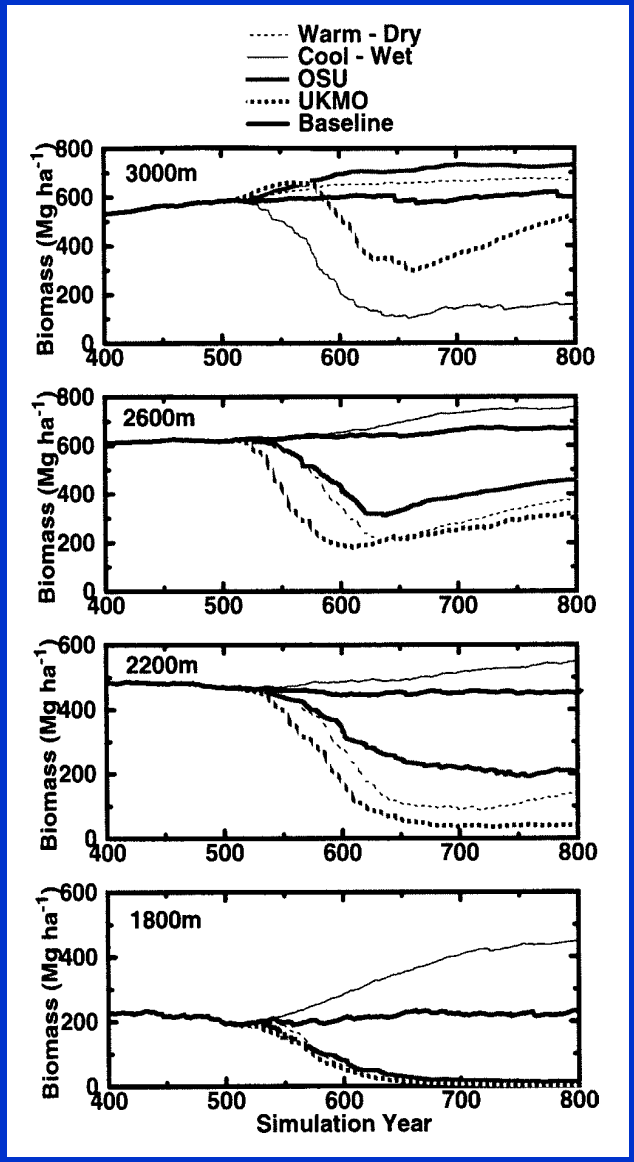




USGS

Projecting possible effects of climatic change on forests

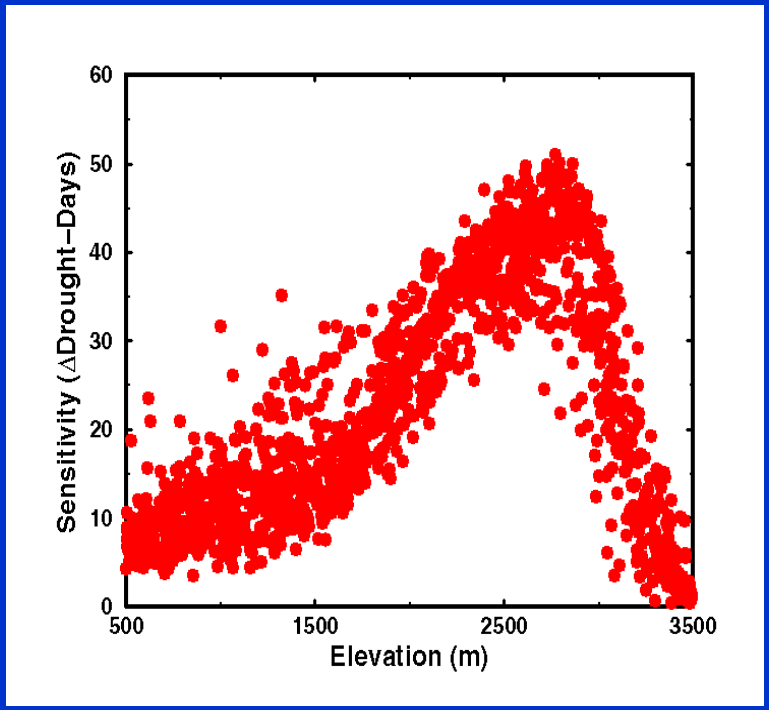




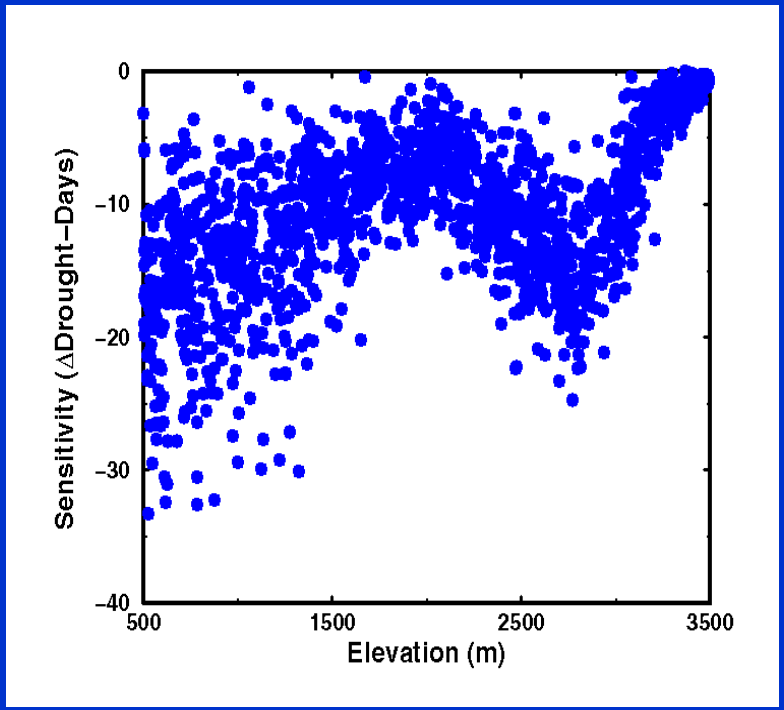
USGS

Predicting sensitivity to climatic change

Temperature

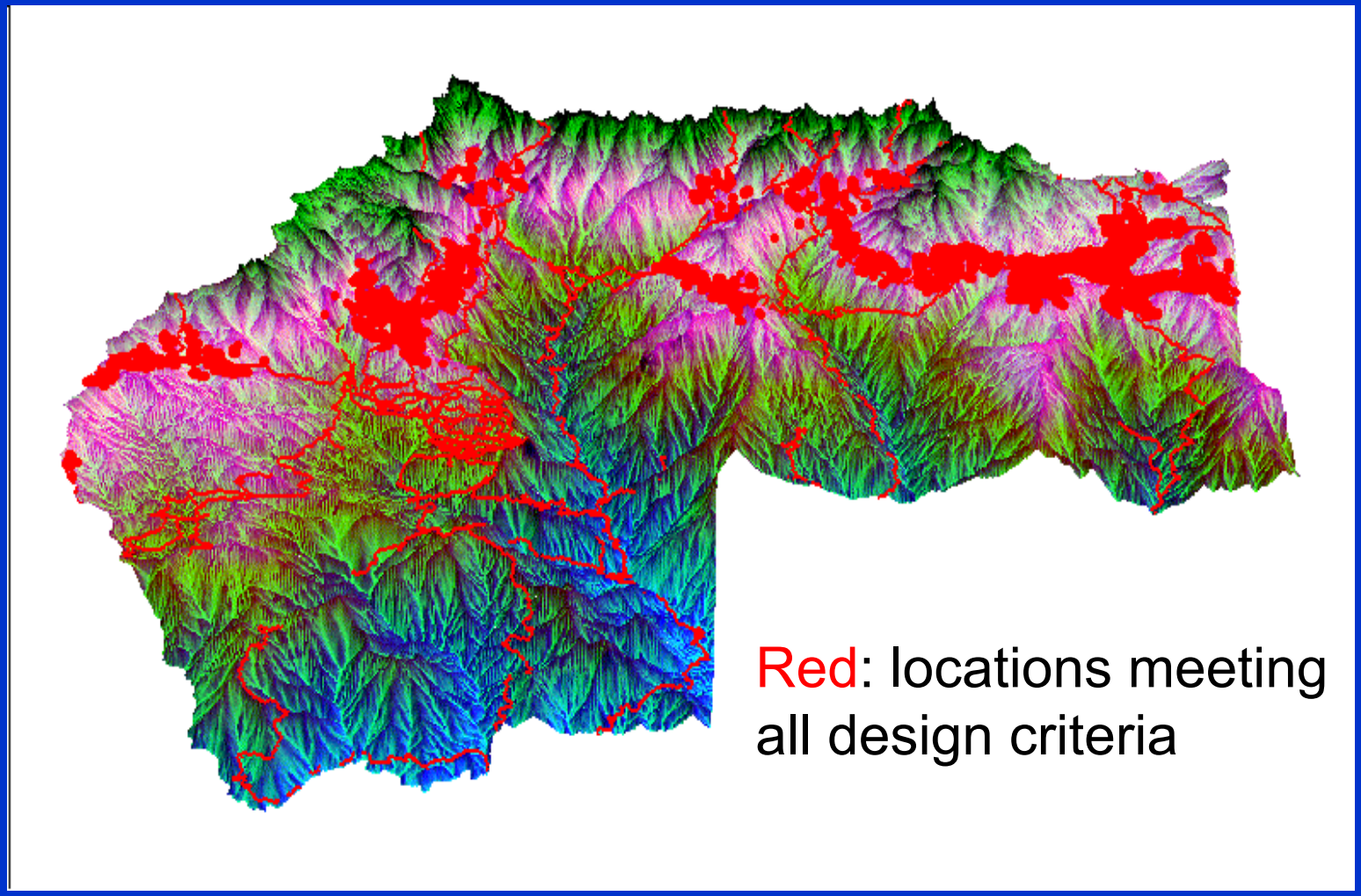


Precipitation



USGS

Detecting change: designing a monitoring network

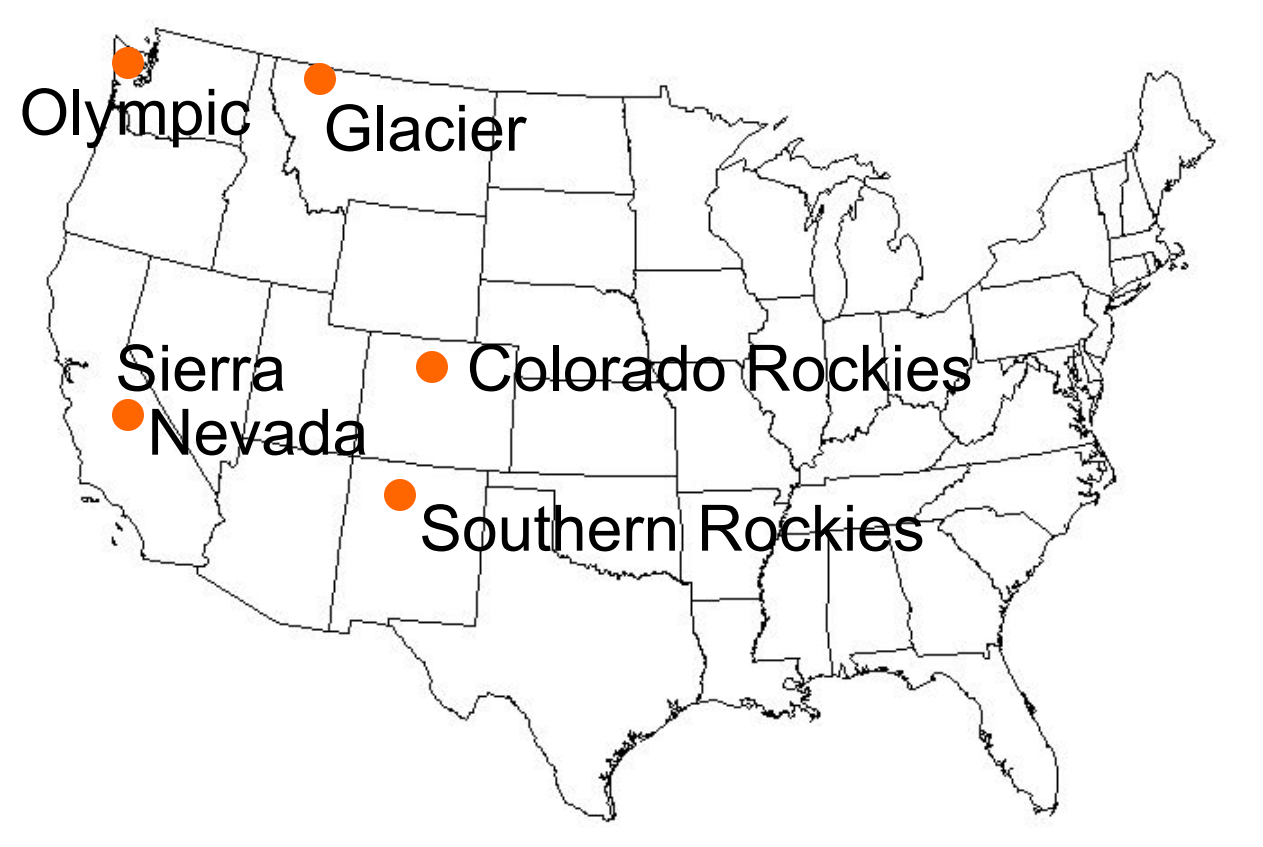


Red: locations meeting all design criteria

USGS

Future research directions ...

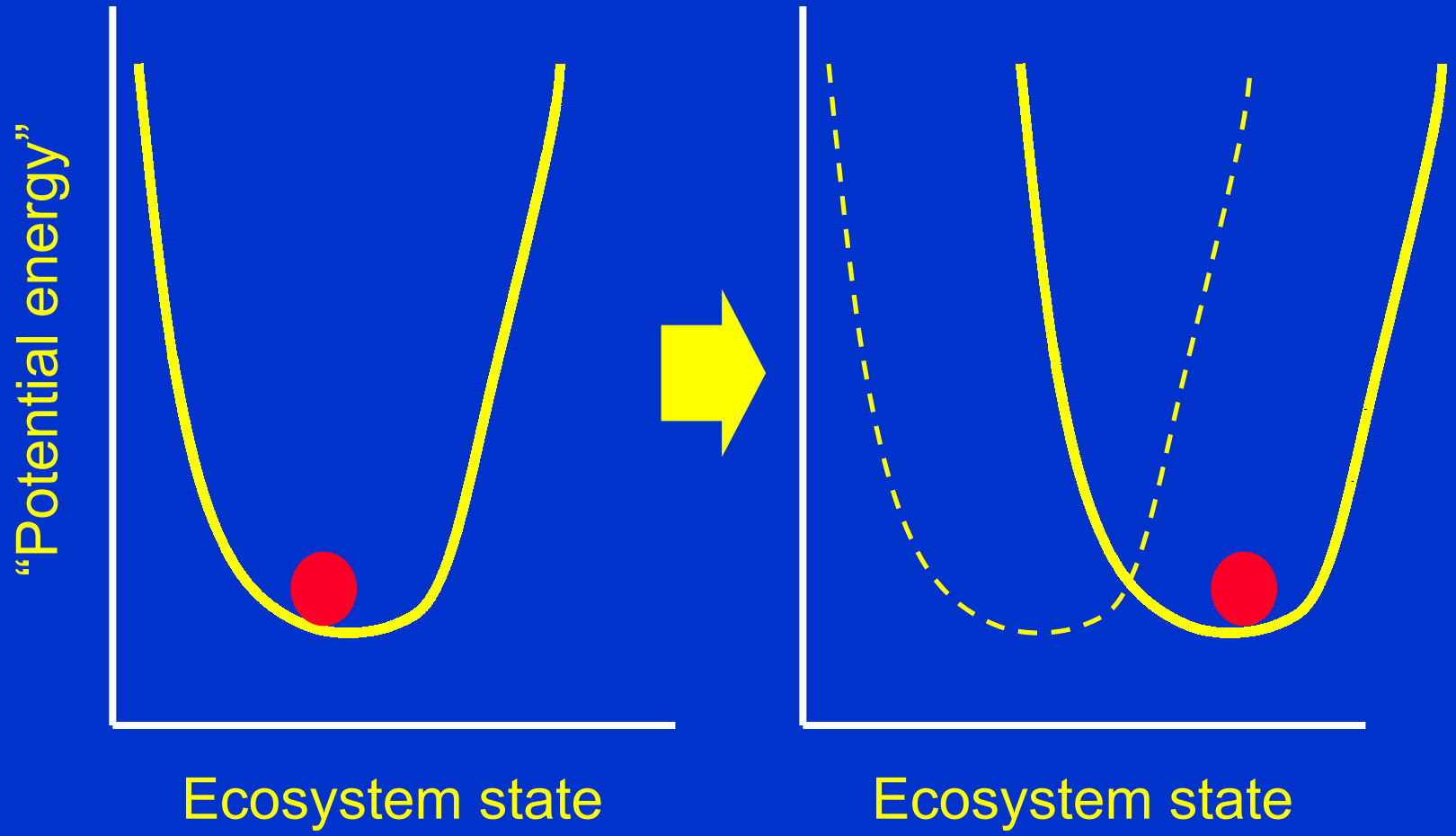
… seek broader generalization through closer integration with the other **Western Mountain Initiative** sites ...



USGS

Future research directions (cont.)

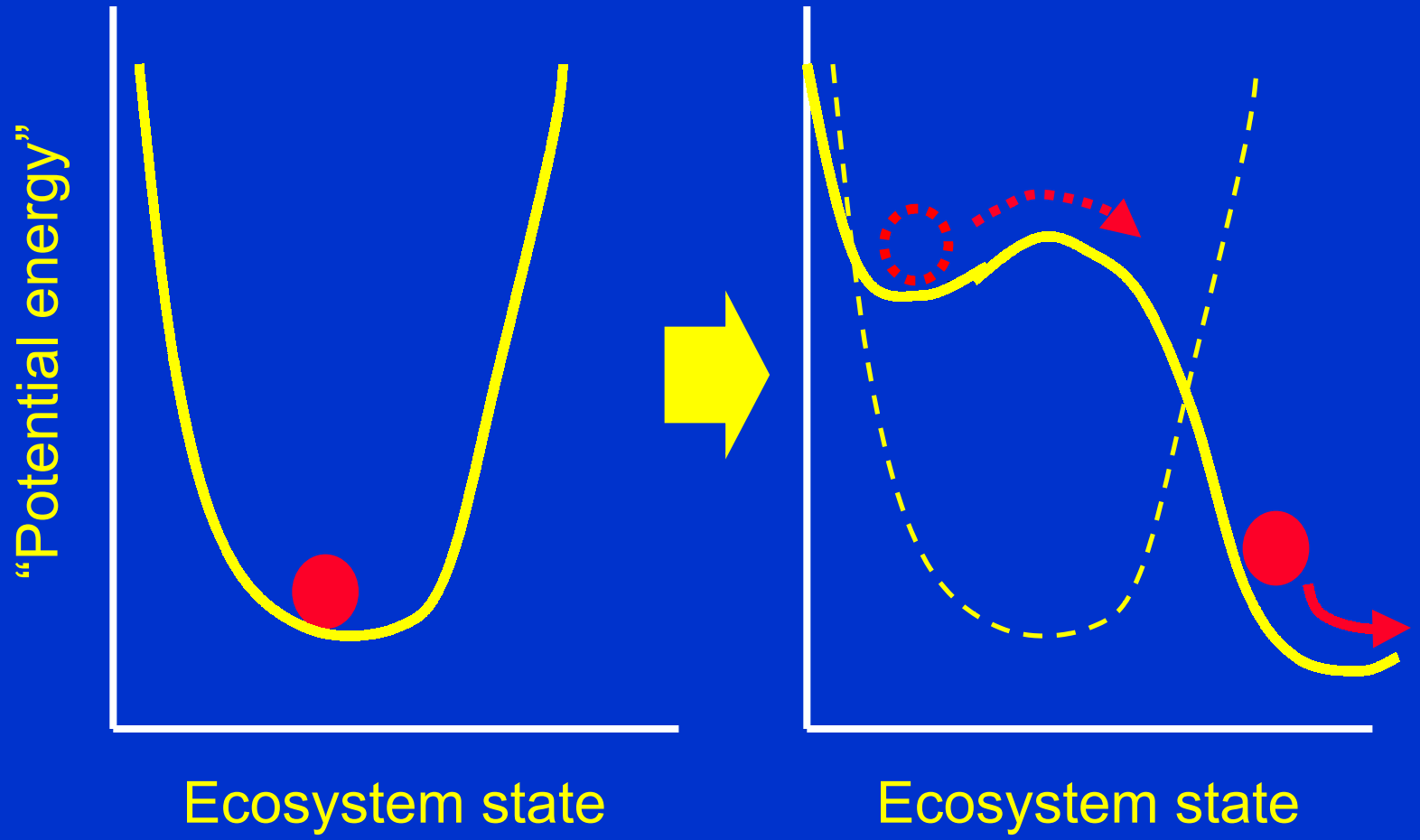
Gradual ecosystem change ...?



USGS

Future research directions (cont.)

… Or sudden, catastrophic change?

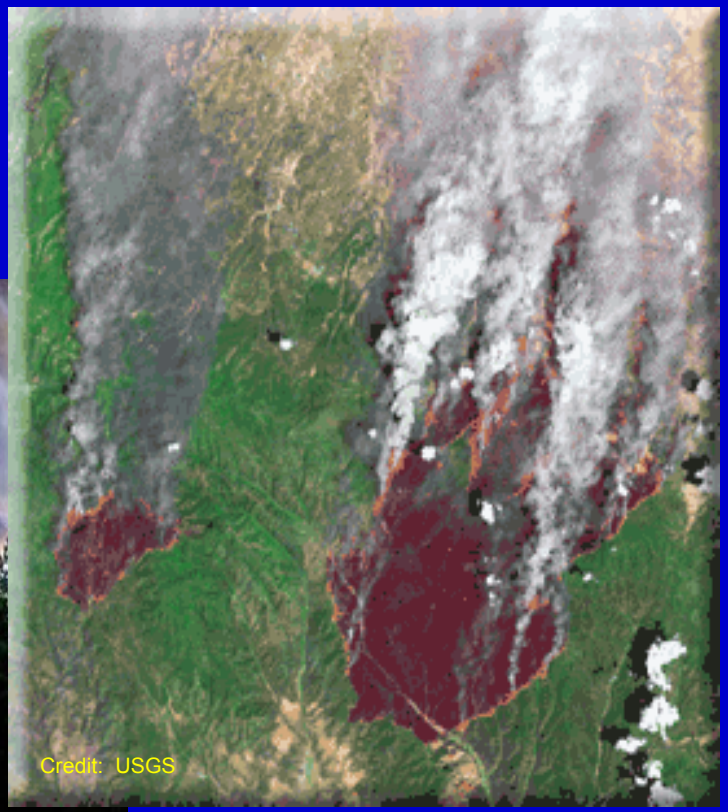


USGS

Future research directions (cont.):
Thresholds, resilience, dynamics of carbon & water

Forest die-off, San Bernardino Mountains, CA, 2002

McNally wildfire, Sierra Nevada, CA, 2002



Rodeo-Chediski wildfire, AZ, 2002

USGS